LONG ISLAND WATER RESOURCES
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RESULTS OF SUBSURFACE EXPLORATION IN THE MID-ISLAND AREA OF WESTERN SUFFOLK COUNTY, LONG ISLAND, NEW YORK

BY
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U. S. GEOLOGICAL SURVEY

WITH A SECTION ON
POTENTIAL DEVELOPMENT OF GROUNDWATER
IN THE MID-ISLAND AREA

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CONTENTS

ILLUSTRATIONS

(Plates are in pocket)

TABLES

RESULTS OF SUBSURFACE EXPLORATION IN THE MID-ISLAND AREA OF WESTERN SUFFOLK COUNTY LONG ISLAND, NEW YORK

by

Julian Soren

ABSTRACT

The mid-island area of western Suffolk County, Long Island, N. Y., comprises an area of about 140 square miles which extends from the western border of the county, at Nassau County, eastward to Lake Ronkonkoma. Population has been expanding rapidly in the area since the end of World War II, and the population was still growing in 1968. Because ground water is the only source of fresh water in the area, the availability and quality of the ground water is of vital concern to local water-management officials and residents. Consequently, a program of test drilling and data collection was undertaken in 1963 to obtain information on the local geohydrology. Results of the work show that the area is underlain by thick unconsolidated aquifers of moderate to high permeability, the water in the aquifers is of good quality for domestic and industrial uses, and that additional high-yield wells can be developed in the area.

Ground-water pumping in the area has increased greatly to maintain adequate supplies for the growing population. In 1968, about 33 million gallons per day was pumped, about 2.5 times the average pumpage in 1958.

The water table in most of the area has declined significantly, mostly as a result of ground-water pumping. From 1903 to 1968, the water-table decline ranged from about 10 feet in the eastern and central parts of the area, to about 30 feet in the western part. Most of the decline apparently occurred in the last two decades. Part of the decline was caused by drought from 1962-66. The decline of the water table reflects the loss of 50-70 billion gallons of ground water from storage.

Ground-water levels will continue to decline in the area unless net ground-water withdrawals are decreased or recharge is increased. Declining ground-water levels will be accompanied by decreased stream and subsurface outflow toward the sea and by salt-water intrusion into the aquifers.

INTRODUCTION

PURPOSE AND SCOPE OF INVESTIGATION

Rapidly increasing population in western Suffolk County, Long Island, N. Y., since the end of World War II, has been accompanied by increasing demands of water for public supply. Ground water is the only source of supply for the area; therefore, ground-water resources are of great concern to water-management officials and the public. Efficient development and management of the area's ground-water resources are dependent on knowledge of the availability and chemical quality of the ground water, and also on the probable effects of continuing large withdrawals from the ground-water reservoir.

In 1963 the U.S. Geological Survey, Suffolk County Board of Supervisors (replaced by Suffolk County Legislature in 1970), and Suffolk County Water Authority began a cooperatively financed study of geohydrologic conditions in the mid-island area of western Suffolk County (referred to as the mid-island area in this report) to obtain information on the ground-water reservoir. The objectives of the study were to:

1. define the extent and character of the aquifers;

2. determine the chemical quality of water in the aquifers;

3. determine hydraulic-head relationships at different depths in the aquifers, in various parts of the area, to determine the directions of ground-water movement; and

4. evaluate the effects of future large ground-water withdrawals on the areal geohydrologic system.

The results of most aspects of the study are summarized in this report. Pertinent data on the geology and hydrology of the area are shown on a series of maps, geologic sections, and hydrographs of wells, and certain water-management implications are considered in the context of these data. Geologic logs of test wells, selected water-quality data, and records of performances of wells are shown in tables.

Detailed information on the step-by-step activities at each test site is given in a series of data releases on file in the offices of the U. S. Geological Survey, Mineola, N. Y., and the Suffolk County Water Authority, Oakdale, N. Y.

METHODS OF INVESTIGATION

A program of test drilling and observation well installation was carried out by the U.S. Geological Survey, in cooperation with the Suffolk County Board of Supervisors and Suffolk County Water Authority, from 1964 to 1968 to (1) obtain detailed subsurface hydrologic and geologic data, (2) measure ground-water levels, and (3) collect ground-water samples for chemical analyses. Most of the test drilling was carried out to depths of about 900 feet; the greatest depth drilled was 1,580 feet. Thirty-two wells, ranging in depth from 29 to 1,300 feet, were installed at seven sites from west to east across the study area. Water samples were collected from 30 of the test wells, and 22 of the wells (from two to four at each site) were retained for continuous measurements of ground-water levels. Partial chemical analyses of more than 200 water samples were made in the laboratory of the Suffolk County Water Authority, and 33 samples were analyzed in detail by the U.S. Geological Survey. The permanent observation wells are screened at different depths, and they serve to measure vertical differences in hydraulic heads at the sites. Additional data, obtained from records of other wells in the area, were also used in the study.

PREVIOUS INVESTIGATIONS

Veatch and others (1906) described many aspects of the geology and compiled the first known water-table map of the area. The surficial geology of the area later was mapped by Fuller (1914). Water-table maps for 1943 were prepared by Jacob (1945) and for 1951 by Lusczynski and Johnson (1951). Suter and others (1949) mapped the geology and aquifers of Long Island. Much of the geology and hydrology of the northern part of the mid-island area was described by Lubke (1964), and Pluhowski and Kantrowitz (1964) described some hydrologic features in the southern part. In addition to the descriptive reports cited, compilations of well logs and other well data were prepared by the U.S. Geological Survey (1938), by Roberts and Brashears (1945), and by Johnson and Waterman (1952).

ACKNOWLEDGMENTS

Water-level and water-quality information were provided by the Suffolk County Water Authority and the Greenlawn Water District. The Lauman Co., Inc., Layne-New York Co., Inc., and Mathies Well and Pump Co., Inc., provided well logs and water-level data. The author gratefully expresses his appreciation for this assistance.

Members of the staff of the Suffolk County Water Authority, notably Messrs. H. F. Gardner, W. J. Schickler, A. A. Guerrera, G. L. Carpenter, and E. J. Kittler, provided valuable assistance in the planning and execution of this investigation.

The field work and report were done under the immediate supervision of Bruce L. Foxworthy and Philip Cohen, hydrologists-in-charge of the Long Island Subdistrict, and under the general direction of Ralph C. Heath, and Garald G. Parker, district chiefs, New York District of the U.S. Geological Survey's Water Resources Division.

GEOGRAPHY

LOCATION AND EXTENT OF AREA

The mid-island area consists of about 140 square miles and comprises a strip about 20 miles long, from west to east, by about 7 miles wide, from north to south in western Suffolk County (fig. 1). The area extends from the Suffolk-Nassau Counties boundary to the village of Lake Ronkonkoma and is approximately bisected along its length by the Long Island Expressway (pl. 1).

TOPOGRAPHY

Most of the western half of the mid-island area is hilly, having a maximum relief of about 290 feet. An irregular ridge having a maximum relief of about 140 feet, trends east to east-northeast across the central part of the mid-island area. The topography north of the ridge is characterized by low rolling hills. South of the ridge, the area is a fairly flat plain which slopes gently southward to the sea. The plain is dissected by several streams, and the maximum relief in this part of the mid-island area is about 40 feet. The distinctive topographic features of the mid-island area mainly resulted from different forms of glacial deposition, which are described in a following section, "Geology and Aquifers."

SURFICIAL DRAINAGE

The easterly trending ridge along the central part of the area constitutes a divide for the area's surface drainage. Streams flow northward in the northern part of the mid-island area into Long Island Sound, and southward in the southern part into Great South Bay. The major northward-flowing streams are Cold Spring Brook, in the northwestern corner of the area, and the Nissequogue River, in the northcentral part. The major southward-flowing streams are, from west to east, Carll's River, Sampawams Creek, Orowoc Creek, Champlin Creek, and Connetquot Brook. (See plate 1.)

CLIMATE

The climate of the mid-island area is temperate and mildly humid. Nearby large bodies of salty water, Long Island Sound to the north and the Atlantic Ocean to the south, have a moderating effect on the air temperature. The average annual temperature is about 12°C (53°F), and the lowest and highest monthly temperatures average about -1 and 23°C (31 and 73°F) in January and July, respectively. Extreme temperatures as low as -23°C (-10°F) and as high as 38°C (100°F) have been measured in the area. The growing season, about 195 days, is generally between mid-April and the end of October, the longest growing season in New York State.

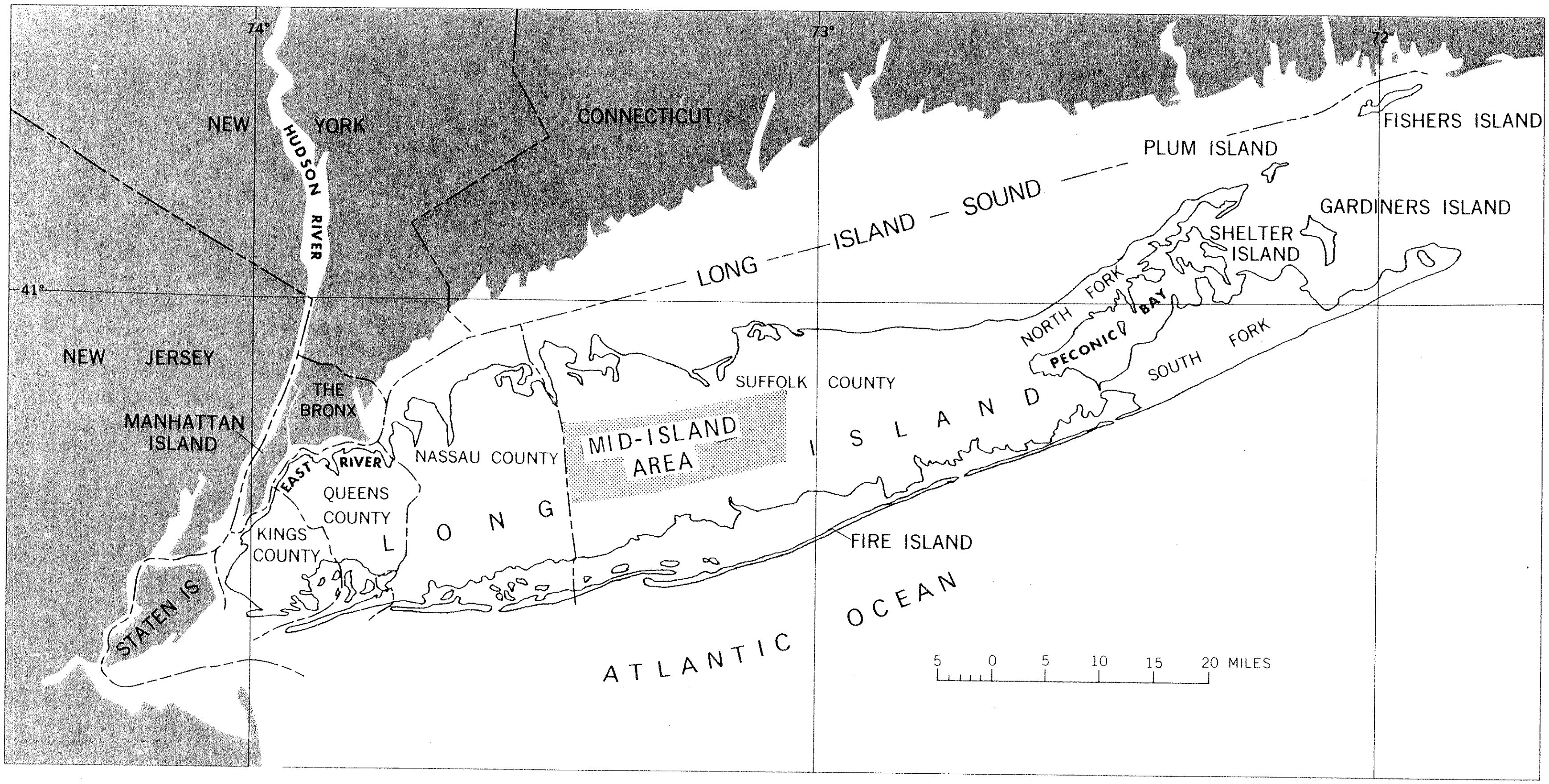

Figure 1.--Index map of Long Island, N. Y., showing location of the mid-island area of western Suffolk County.

Long-term average annual precipitation ranges from about 46 inches, at the western end of the mid-island area, to about 55 inches in the vicinity of Lake Ronkonkoma. Precipitation generally is fairly evenly distributed throughout the year. Drought conditions occurred from 1962 to 1966, and during this period, average annual precipitation ranged from about 37 inches in South Huntington to about 40 inches at Lake Ronkonkoma.

POPULATION AND CULTURE

The project area includes large parts of the Towns of Huntington, Smithtown, and Islip, and small parts of the Towns of Babylon and Brookhaven. People live in small to moderately large, rapidly growing, unincorporated residential communities within the towns. Population growth in the largest communities is shown in the following tabulation:

Community	Town	Population		
		U.S. Census		Estimated 1/
		1950	1960	1968
Central Islip	Islip	--	27,068	44,131
Brentwood	do.	2,803	15,387	26,940
South Huntington	Huntington	1,274	7,084	8,849

1/ Information supplied by Long Island Lighting Co., Mineola, N. Y.

The mid-island area is mainly residential, populated largely by commuters who work in New York City. However, several light-industry centers and single plants are in the area. The area also contains some agriculture, producing mainly potatoes, cabbage, cauliflower, and other garden vegetables, corn, wheat, and rye, but farm acreage is dwindling. Two large state-owned hospitals are in the area, Central Islip State Hospital in Central Islip, and Pilgrim State Hospital in Brentwood.

Transportation needs of the area are served mainly by many through multiple-lane motor highways and connecting local streets. The Long Island Railroad traverses the southern part of the area, and a small part in the northwest. MacArthur Airport, a large commercial-aviation facility, is situated in Bohemia in the southeastern part of the area, and a small private airport is located near the center of the area in the northern part of Deer Park.

The major communities, motor roads, and other transportation facilities in the mid-island area are shown in plate 1.

GEOHYDROLOGY

GEOLOGY AND AQUIFERS

Unconsolidated deposits, ranging in age from Late Cretaceous to Pleistocene, underlie the mid-island area. These deposits contain several major aquifers and constitute the ground-water reservoir. Thin surficial Holocene deposits of soil and some swamp accumulations occur from place to place, but these are of little significance to the ground-water reservoir. The unconsolidated deposits rest unconformably on crystalline bedrock consisting of Precambrian (?) schist and gneiss which is considered to be the bottom of the ground-water reservoir on Long Island.

The unconsolidated deposits, from the bedrock upward, include the Lloyd Sand Member and clay member of the Raritan Formation of Late Cretaceous age, the Matawan Group-Magothy Formation, undifferentiated, also of Late Cretaceous age, and glacial deposits of Pleistocene age. The major aquifers in the area are the deposits of sand and gravel in the Pleistocene and the Matawan-Magothy strata. The test drilling described previously was carried out mostly to the depth of the upper part of the clay member. Therefore, the drilling served to determine the base of the Matawan-Magothy deposits. The drilling also served to obtain information on the configuration of the top of the Matawan-Magothy deposits, which were deeply eroded during Tertiary and, probably, Pleistocene time.

BEDROCK OF THE PRECAMBRIAN (?) SYSTEM

The Precambrian (?) gneiss and schist which underlies Long Island is hard and dense. Virtually all the water in these rocks is found in joints, faults, and foliation planes. Because these openings are usually tight and poorly connected, the bedrock is practically impermeable, especially by comparison with the overlying unconsolidated formations. No wells are known to tap bedrock in the mid-island area.

The bedrock was eroded to a peneplain prior to the deposition of the Cretaceous strata. In the mid-island area, the bedrock surface dips gently southeast at an average slope of about 65 feet per mile (about two-thirds of a degree), and its altitude ranges from about 800 feet below sea level in the northwestern corner of the area to about 1,600 feet below sea level in the southeastern part (pl. 2).

UPPER CRETACEOUS SERIES

Raritan Formation

Lloyd Sand Member

The Lloyd Sand Member of the Raritan Formation comprises the Lloyd aquifer on Long Island. This unit consists mostly of beds and lenses of light- to medium-gray sand and gravelly sand, commonly containing small to large amounts of interstitial clay and silt, that are intercalated with beds and lenses of light- to dark-gray clay, silt, and clayey and silty sand.

Only two drill holes are known to have penetrated the Lloyd in the mid-island area. One hole partly penetrated the unit at the Pilgrim State Hospital, in Brentwood. The second hole, which is in the village of Lake Ronkonkoma, and which was one of the test holes drilled as part of this study, fully penetrated the unit. A log of the test hole describing lithology of the Lloyd is shown in table 1, S33379.

The surface of the Lloyd is roughly parallel to the bedrock surface. The Lloyd surface dips from an altitude of about 550 feet below sea level in the northwestern part of the area, to an altitude of about 1,250 feet below sea level in the southeastern part (pl. 2), and the unit's thickness ranges from about 260 feet to 360 feet from northwest to southeast, respectively. Plate 2 shows contours on the Lloyd surface. Plate 2 also shows contours on the bedrock surface; therefore, the Lloyd's thickness, in any part of the area, can be estimated by computing the local difference between the altitudes of the bedrock and Lloyd surfaces.

The Lloyd aquifer is moderately permeable. Its average horizontal permeability has been estimated by Lusczynski and Swarzenski (1966, p. 19), Isbister (1966, p. 20), and Soren (in press) to range between 400 and 500 gpd per sq ft (gallons per day per square foot) in Queens and Nassau Counties, west of the mid-island area. Warren and others (1968, p. 102) estimated the Lloyd's horizontal permeability to be 165 gpd per sq ft at the Brookhaven National Laboratory, about 12 miles east of the mid-island area. The section of Lloyd penetrated by the test well near Lake Ronkonkoma was fairly sandy and gravelly (table 1, S33379), and at this site the average horizontal permeability of the Lloyd probably is considerably more than 500 gpd per sq ft. Wells tapping the Lloyd in other parts of Long Island have been pumped at rates of as much as 1,600 gpm (gallons per minute), and the specific capacities of these wells (pumpage, in gallons per minute, divided by drawdown, in feet) have been reported to range from 3 to 40 gpm per foot of drawdown.

At present, there is no pumpage from the Lloyd aquifer in the mid-island area, mainly because of the great depth of the aquifer, and because more permeable aquifers are found at shallower depths. In addition to being at a greater depth, the water from the Lloyd commonly has undesirably high concentrations of iron.

Clay Member

The clay member of the Raritan Formation (commonly referred to as the Raritan clay) completely covers the underlying Lloyd aquifer in the mid-island area, and confines water in that aquifer. The Raritan clay consists mostly of beds and lenses of light- to dark-gray clay, silt, and clayey and silty fine sand (table 1). Thin to thick sandy beds commonly occur in the unit from place to place, but these beds do not have great lateral extent. Laminae and thin beds of lignite and pyrite and disseminated particles of these substances are common in the clay beds of the unit. The thickness of the Raritan clay increases to the southeast, and ranges from about 150 feet in the northwestern part of the mid-island area to about 200 feet in the southeastern part.

The surface of the Raritan clay is roughly parallel to that of the underlying Lloyd Sand Member. The altitude of the surface of the Raritan clay ranges from about 300 feet below sea level in the northwestern part of the mid-island area, to about 1,050 feet below sea level in the southeastern part (pl. 3).

Matawan Group-Magothy Formation, Undifferentiated

The Matawan Group-Magothy Formation, undifferentiated, comprises the Magothy aquifer of Long Island. Deposits in this unit consist of beds and lenses of light-gray fine to coarse sand, containing traces to large amounts of interstitial clay and silt, intercalated with thin to thick beds and lenses of light- to dark-gray clay, silt, and clayey and silty sand (table 1). The clay and silt beds commonly contain laminae and thin beds of lignite. Disseminated lignite and pyrite also are common in the sand beds of the aquifer. Gravelly coarse sand is commonly found in the basal part of the aquifer. This coarse zone ranges in thickness from 100 to 150 feet west of the mid-island area to 150 to 200 feet in the mid-island area. The basal zone also commonly contains abundant interstitial clay and silt and many thin to thick beds and lenses of clay, silt, and clayey and silty sand.

The surface of the Magothy aquifer (pl. 4) is not planar as are the surfaces of the underlying units. The Magothy surface was deeply eroded during Tertiary time, and probably was considerably eroded in Pleistocene time. Consequently, the depth to the Magothy aquifer and the aquifer's thickness cannot be predicted as accurately as the depths and thicknesses of the underlying units. Many control points in addition to those already known are needed to accurately map the upper surface of the Magothy aquifer.

The highly irregular character of the surface of the Magothy aquifer is shown in plate 4. The upper surface of the aquifer ranges in altitude from as high as about 200 feet above sea level to as low as about 500 feet below sea level. The Magothy was completely removed by erosion in a buried valley near the South Huntington area, and in that area upper Pleistocene deposits lie directly on the Raritan clay. This buried valley was called the "Huntington buried valley" by Lubke (1964, pl. 3), and as mapped by Lubke, the valley extended about 2-1/2 miles south of the Northern State Parkway.

Information from wells drilled after Lubke's investigation indicates that the Huntington buried valley continues southeastward, joining another buried valley in the Deer Park area. From Deer Park, the valley appears to extend southeastward across Long Island to the Fire Island Pines area of Fire Island, about 10 miles southeast of Deer Park, where the Magothy surface was shown to be about 350 feet below sea level by Perlmutter and Todd (1965, pl. 8).

The Huntington and Deer Park buried valleys are separated by a divide across the buried valley system in the Deer Park area. The Huntington buried valley slopes steeply northwestward from the divide; the Deer Park buried valley has a gentle southward slope toward the Fire Island Pines area. The divide across the valley approximately coincides with the southern margin of the Ronkonkoma terminal moraine. (See the following section, "Pleistocene Series.") The steeper Huntington buried valley was probably overdeepened by scouring action of Pleistocene glaciation. Other buried valleys in the northern part of the mid-island area (pl. 4) are not as deep nor as extensive as the Huntington and Deer Park buried valleys.

A large depression in the Magothy surface is apparent in the St. James-Ronkonkoma area. Lubke (1964, pl. 3) showed the Magothy surface to be more than 200 feet below sea level in this area. More recent information indicates that the Magothy surface in this area is more than 500 feet below sea level (pl. 4). This large depression is here called the Ronkonkoma basin (pls. 4-5). The precise origin of this basin is not known, but it probably was at least partly a result of Pleistocene glacial scouring of a pre-existing valley system. The depression appears to have had no outlet, and its southernmost end coincides approximately with the southern margin of the Ronkonkoma terminal moraine.

Representative thicknesses of the Magothy aquifer are shown in geologic sections in plate 5. In these sections, the thickness of the Magothy ranges from about 300 to 800 feet. The estimated thickness of the Magothy aquifer in any part of the mid-island area can be computed by determining the difference between altitudes of the Magothy and Raritan surfaces as shown in plates 3 and 4. The Magothy aquifer is thickest (about 950 feet) in the southeastern corner of the project area, and it is thinnest in the bottom of the buried valleys. As previously noted, the aquifer is completely missing in part of the buried valley near South Huntington (pl. 4).

The permeability of the Magothy aquifer ranges widely. The estimated average horizontal permeability of the aquifer is about 500 gpd per sq ft in Nassau and Queens Counties (Lusczynski and Swarzenski, 1966, p. 19; Isbister, 1966, p. 23-24; and Soren, in press); however, the permeabilities of some beds in the aquifer may be as high as 2,000 gpd per sq ft (Isbister, 1966, p. 23). Public-supply wells screened in the Magothy aquifer of the mid-island area have yielded as much as 1,700 gpm, with specific capacities ranging from about 14 to 85 gpm per ft of drawdown.

PLEISTOCENE SERIES

Upper Pleistocene deposits

Pleistocene deposits of glacial origin mantle the surface of the mid-island area (pl. 1) and range in thickness from a few tens of feet in some localities to more than 600 feet in buried valleys. The approximate thickness of Pleistocene deposits at any place generally can be computed by determining the difference between the altitude of the land surface and the altitude of the surface of the Magothy aquifer.

Most and perhaps all the glacial materials on Long Island were deposited in Wisconsin time, and these materials generally are collectively termed upper Pleistocene deposits. The upper Pleistocene deposits in the mid-island area include terminal moraines, outwash deposits, ground moraine, and lake deposits. The Harbor Hill and Ronkonkoma terminal moraines form the irregular ridges trending east-northeast across the area. Outwash deposits derived from melted glacial ice lie south of the Ronkonkoma terminal moraine. Glacial lake deposits, which apparently were formed between the Ronkonkoma and Harbor Hill advances of the glaciers, lie within outwash deposits below the land surface, and occur mostly between the terminal moraines in the eastern half of the area, most notably in the Smithtown-St. James-Ronkonkoma area.

Ronkonkoma Terminal Moraine

The Ronkonkoma terminal moraine marks the farthest advance of glaciation on Long Island. The moraine is composed largely of crudely stratified sand and gravel. It underlies the highest parts of the mid-island area, tapering from an irregular broad band in the western part, to an irregular narrow ridge in the eastern part. (See plate 1.) The unit lies mostly above the water table and is, therefore, practically of no significance as a source of ground water; however, it is a difficult unit to drill through because of the large amounts of gravel, cobbles, and scattered boulders that it contains.

Harbor Hill Terminal Moraine

Only a very small part of this moraine is found in the mid-island area, in the extreme northwest corner near South Huntington (pl. 1). Most of this moraine is north of the mid-island area. The moraine's lithology and water-bearing characteristics are similar to those of the Ronkonkoma terminal moraine.

Outwash Deposits

The outwash deposits, which are found south of the Ronkonkoma terminal moraine and between the Harbor Hill and Ronkonkoma terminal moraines (fig. 2), are beds of sand and gravel that were deposited by glacial melt water. The

source of the rock materials in the outwash deposits is manifold. As the glaciers moved southward to Long Island, they plucked the bedrock and soils of the surfaces they slid over. Rock materials were incorporated into the ice in contact zones and were also pushed along the glacial front. As the ice melted in late Pleistocene time, the various rock materials were carried away by broad coalescing streams and sheets of water. Consequently, the outwash deposits are stratified, and because of the varied materials carried by the glacier, these deposits consist of a heterogeneous suite of rock types. The great diversity of rock and mineral suites in the Pleistocene deposits, along with the chemically unstable (easily decomposed) rocks and minerals, commonly facilitates differentiation of glacial from the Cretaceous deposits on Long Island.

Outwash deposits underlie the plain in the mid-island area south of the Ronkonkoma terminal moraine, where the major source of glacial deposition was material from the Ronkonkoma ice advance. A readvance of the glacial front followed recession of the Ronkonkoma ice front and resulted in the formation of the Harbor Hill terminal moraine. Lakes were formed in depressions and valleys between the Ronkonkoma and Harbor Hill terminal moraines, and clayey materials were deposited in these lakes. The inter-morainal areas also contain recessional deposits of outwash and ground moraine (see the following section, "Ground-Moraine Deposits") from the Ronkonkoma and Harbor Hill deglaciations, and these materials buried the clayey lake deposits.

The outwash deposits are thickest in the buried valleys and thinnest where the Cretaceous surface is closest to land surface (pl. 5). These deposits generally extend below the water table, and are a major source of ground water. Outwash deposits comprise most of the so-called upper glacial aquifer of Long Island, and because these deposits of sand and gravel contain virtually no interstitial clay and silt, the upper glacial aquifer is the most permeable aquifer on Long Island. The estimated average horizontal permeability of the outwash deposits is about 1,000 to 1,500 gpd per sq ft (Lusczynski and Swarzenski, 1966, p. 17; and Soren, in press). Warren and others (1968, p. 75) computed the horizontal permeability of outwash to be about 1,300 gpd per sq ft at the Brookhaven National Laboratory, east of the mid-island area. A horizontal permeability for outwash as high as about 2,500 gpd per sq ft has been reported in Nassau County, west of the project area (Isbister, 1966, p. 29).

Public-supply and other high-capacity wells screened in glacial outwash on Long Island have yielded as much as 1,700 gpm, and reported specific capacities of such wells range from less than 10 gpm per foot of drawdown to as much as about 200 gpm per foot of drawdown; however, the specific capacities range mostly from 50 to 100 gpm per foot of drawdown. (See section "Yields of Individual Wells.")

Ground-Moraine Deposits

Ground-moraine deposits commonly consist of unstratified and unsorted clay, silt, sand, gravel, cobbles, and boulders, deposited on the land surface as the glacial fronts receded. Ground-moraine deposits from the Ronkonkoma advance probably occur beneath the outwash in the area between the Ronkonkoma and Harbor Hill terminal moraines. Some ground-moraine deposits probably were partly reworked by glacial melt water from the Harbor Hill advance and probably appear similar to outwash in drilling samples.

Lake Deposits

A large lake apparently existed between the Ronkonkoma and Harbor Hill terminal moraines in the previously described Ronkonkoma basin. Deposits of light- to dark-brown and gray clay and silt of lacustrine origin, with some included beds of sand and gravel, occur between deposits of outwash in this area. The deposits are informally known as the Smithtown clay unit or Smithtown clay, and they were mapped and described by Lubke (1964, p. 22 and 26) as the "clay unit of Smithtown." Thin to significant thicknesses of this unit were penetrated at four of the test-drilling sites in the eastern half of the mid-island area. (See plate 5 and table 1, S22577, S22910T, S24769, and S24772). Apparently, it is thickest near the community of Lake Grove (not shown in plate 1) about 2.5 miles north of Lake Ronkonkoma, where about 300 feet of Pleistocene clay beds were penetrated in a drilled test hole (Jensen, H. M., oral commun., 1969).

Smaller glacial lakes probably also existed in other parts of the intermorainal area. Many drilling logs from localities in the area indicate thin intercalated clay and fine sand beds between sand and gravel deposits. The extent of these lakes is not fully known, and they were probably small compared to the lake in which the Smithtown clay was deposited.

Veatch and others (1906, p. 61) suggested that present Lake Ronkonkoma, in the eastern part of the mid-island area, is in a depression made by a large ice block that was detached from the main glacial-front mass and buried by outwash deposits. Subsequent melting of the ice block presumably caused the depression in the land surface which then filled with water. Inasmuch as this study has shown that present Lake Ronkonkoma is in the Ronkonkoma basin, it seems possible that the location of the lake may merely reflect the fact that the ancient Ronkonkoma basin was not completely filled by glacial deposits.

The lake deposits do not yield significant quantities of water to wells because they are fine-textured and, accordingly, poorly permeable. However, the lake beds are hydrologically significant because they confine water in the underlying outwash deposits.

Miscellaneous Deposits

The Mannetto Gravel, of Pliocene age, and the Gardiners Clay, a Pleistocene interglacial marine deposit of pre-Wisconsin age, are two additional units of hydrologic signifiance in some parts of Long Island. However, their location and extent in the project area are poorly known, and they seem to occur in only a small part of the area.

The Mannetto Gravel was described and mapped by Fuller (1914, p. 80-85) from the western edge of the mid-island area to about as far east as the area between Wyandanch and Deer Park. The unit reportedly crops out at the tops of high hills, or near the crests of high hills capped by Ronkonkoma terminal moraine deposits. The author could not verify the location and extent of the Mannetto; consequently, the unit is not shown on the surficial geology map (pl. 1).

The Gardiners Clay is an interglacial marine deposit of Sangamon age. It is generally found in the south shore areas of Long Island where the depth to its surface is commonly 40 or more feet below sea level. The Gardiners Clay overlies Matawan-Magothy strata south of the mid-island area (Perlmutter and Todd, 1965, pl. 8), and some clay beds reported by well drillers in the southern part of the buried valley near Deer Park may be Gardiners Clay. However, this is uncertain, and the unit may not be present in the project area.

GROUND-WATER SYSTEM

SOURCE AND MOVEMENT OF GROUND WATER

The ground water on Long Island has its origin in precipitation that falls on the island. According to Cohen and others (1968, p. 36, 40, and 44), the precipitation on Long Island is disposed of as follows: nearly half returns to the atmosphere by evapotranspiration; a very small amount enters streams by direct runoff; and the remaining half percolates downward through the unconsolidated deposits to the water table and enters the ground-water reservoir.

The general ground-water movement on Long Island is from recharge areas near the center of the island to discharge areas at and near the shorelines. Ground water discharges by seepage into streams and by direct subsurface outflow into salty ground water, which in turn is hydraulically connected with bodies of salty surface water.

The horizontal components of the directions of ground-water flow in the upper glacial aquifer are shown in plate 6. In the vicinity of the major ground-water divide in the mid-island area (pl. 6), ground water generally moves downward from the upper glacial aquifer into the Magothy aquifer, and thence through the Raritan clay into the Lloyd aquifer. The vertical components of downward flow decrease with increasing distance both northward and southward of the divide. Beyond the northern and southern margins of the mid-island area, ground-water flow becomes virtually horizontal. Near

the shorelines, the direction of flow is reversed, and ground-water movement is upward from the deeper aquifers toward the surface. Thus, because of the character of the flow system, under natural conditions virtually all the recharge to the Magothy and Lloyd aquifers in western Suffolk County originated in the mid-island area, and all of that recharge ultimately discharged from the ground-water system near the shorelines.

The movement of ground water through Long Island's aquifers in the horizontal direction is generally more rapid than movement in the vertical direction because of the occurrence of interbedded fine- and coarse-grained layers, and because the largest dimensions of unevenly shaped particles in the individual layers tend to be oriented horizontally. Approximate rates of ground-water movement can be computed from hydraulic gradients and estimated coefficients of permeability and porosities of the aquifers. In 1968, water in the upper glacial aquifers in the project area was moving horizontally at rates from less than 0.5 foot per day at points distant from centers of pumping, to hundreds of feet per day near the screens of pumping wells. At the same time, water in the Magothy aquifer was moving horizontally at rates from less than 0.2 foot per day at points distant from pumping, to hundreds of feet per day near the screens of pumping wells.

HYDRAULIC INTERCONNECTION OF AQUIFERS

The aquifers of Long Island are hydraulically interconnected. Layers of clay and silt within an aquifer or between aquifers serve to confine water below them, but they do not completely prevent the vertical movement of water through them. Ground water moves downward readily through coarse outwash deposits in the upper glacial aquifer. Vertical movement of water through the Magothy aquifer is impeded by beds and lenses of clay and silt. Because the clay and silt strata in the Magothy are not continuous, some water may move around lenses of this material in addition to moving slowly through the fine-grained strata.

The contact between the upper glacial and Magothy aquifers is not regular either in attitude or in composition of the contact surfaces. Glacial deposits in buried valleys are in lateral contact with truncated sandy beds in the Magothy. In the buried valleys water can laterally enter the Magothy at great depth directly from the glacial deposits, rather than the water having to move vertically to the same depth through less permeable Magothy beds. In the Huntington buried valley, glacial deposits extend completely through the Magothy aquifer to the underlying Raritan clay. (See plate 4.) In addition to the good hydraulic continuity between the upper glacial and Magothy aquifers in the buried valleys, good hydraulic continuity occurs between the aquifers outside the buried valleys where glacial sand and gravel deposits lie directly on Magothy sand beds. Thus, a fairly good hydraulic connection exists between the upper glacial and Magothy aquifers over large parts of the mid-island area, and the configuration of the piezometric surface of the Magothy aquifer is generally similar to that of the water table. However, in the mid-island area hydraulic heads in the Magothy are lower than those in the upper glacial aquifer because of the downward component of ground-water movement in the area.

The thick areally persistent Raritan clay that lies between the Magothy and Lloyd aquifers impedes but does not prevent downward movement of ground water into the Lloyd aquifer, and water in the Lloyd is tightly confined between the Raritan clay and bedrock. Downward leakage into the bedrock is negligible.

Figures 2 and 3 show hydrographs of wells screened in the upper glacial aquifer and the Magothy aquifer at the test-drilling sites in Brentwood and Hauppauge. At both sites, the heads in the deepest wells in the Magothy aquifer are about 2.5 to 3 feet lower than the heads in the shallowest wells in the upper glacial aquifer. The loss of head downward reflects the downward movement of ground water in the mid-island area. The hydrographs in figures 2 and 3 show that the heads in these two aquifers in the project area decrease at a fairly uniform rate with increasing depth. In addition, water-level fluctuations in the two groups of wells were very similar. Both of these facts, the uniform decrease in head and the similar water-level fluctuations, reflect the high degree of hydraulic interconnection between the upper glacial and Magothy aquifers.

The average vertical permeability of the Magothy aquifer is only poorly known. Estimates range from less than 1 to about 30 gpd per sq ft. Assuming that it averages about 5 gpd per sq ft in the mid-island area, the computed amount of downward ground-water movement through the Magothy aquifer in the vicinity of the ground-water divide in 1968 was about 0.4 mgd (million gallons per day) per square mile, and the estimated velocity of the downward movement was about 0.006 foot per day.

Because of the low permeability of the Raritan clay, the hydraulic-head loss across this unit is very much larger than the head loss across a comparable thickness of the Magothy and upper glacial aquifers. At the easternmost test site in the village of Lake Ronkonkoma, wells were screened near the base of the Magothy and near the top of the Lloyd aquifers (pl. 5, section A-A', S33379-80). In 1968, the head near the base of the Magothy aquifer (about 45.5 feet above sea level) was about 11.5 feet higher than the head in the Lloyd aquifer (about 34 feet above sea level). Head losses across the Raritan clay at localities east and west of the Lake Ronkonkoma area differ considerably. At Upton, about 12 miles east of the mid-island area, the head loss across the clay was about 6 feet in 1968; and at Plainview (in Nassau County), about 3 miles southwest of Melville, the head loss across the clay was about 42 feet. The differences in head loss from place to place are largely a result of differences in the vertical permeability and thickness of the Raritan clay.

The head in the Lloyd aquifer at Lake Ronkonkoma in 1968 (about 34 feet above sea level) was higher than either of the heads in the Lloyd at Upton (about 30.5 feet above sea level) and at the Suffolk-Nassau boundary (about 27.5 feet above sea level). The head in the Lloyd at Terryville, about 7 miles northeast of the Ronkonkoma area was about 21 feet above sea level in 1968, and it was 19 feet above sea level at Fire Island State Park in 1968, about 13 miles to the southwest. These data suggest that water in the Lloyd aquifer is moving radially from the Lake Ronkonkoma area. The estimated rate of horizontal movement of water in the Lloyd aquifer in the project area in 1968, was on the order of 0.1 foot per day.

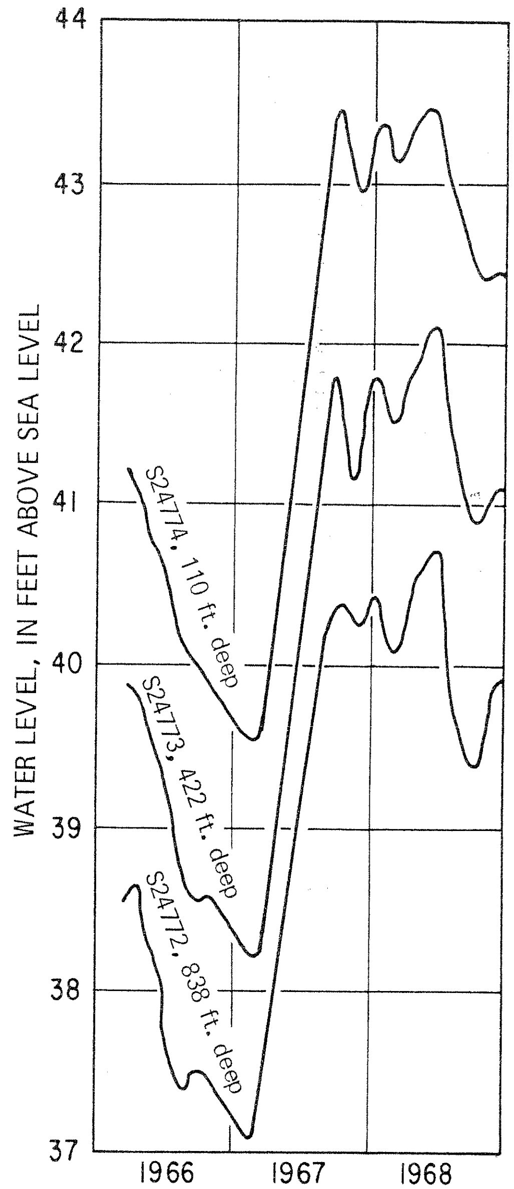

Figure 2.--Fluctuations of water levels in wells screened in the upper glacial aquifer and the Magothy aquifer at Brentwood, N. Y.

FLUCTUATIONS OF GROUND-WATER LEVELS

Fluctuations of water levels in the wells of the mid-island area reflect local variations in recharge to and discharge from the aquifers tapped by the wells. Therefore, changes in ground-water levels afford an insight into many aspects of the ground-water system. Furthermore, the information on water-level fluctuations can be used to help assess the impact of urbanization on the natural hydrologic system.

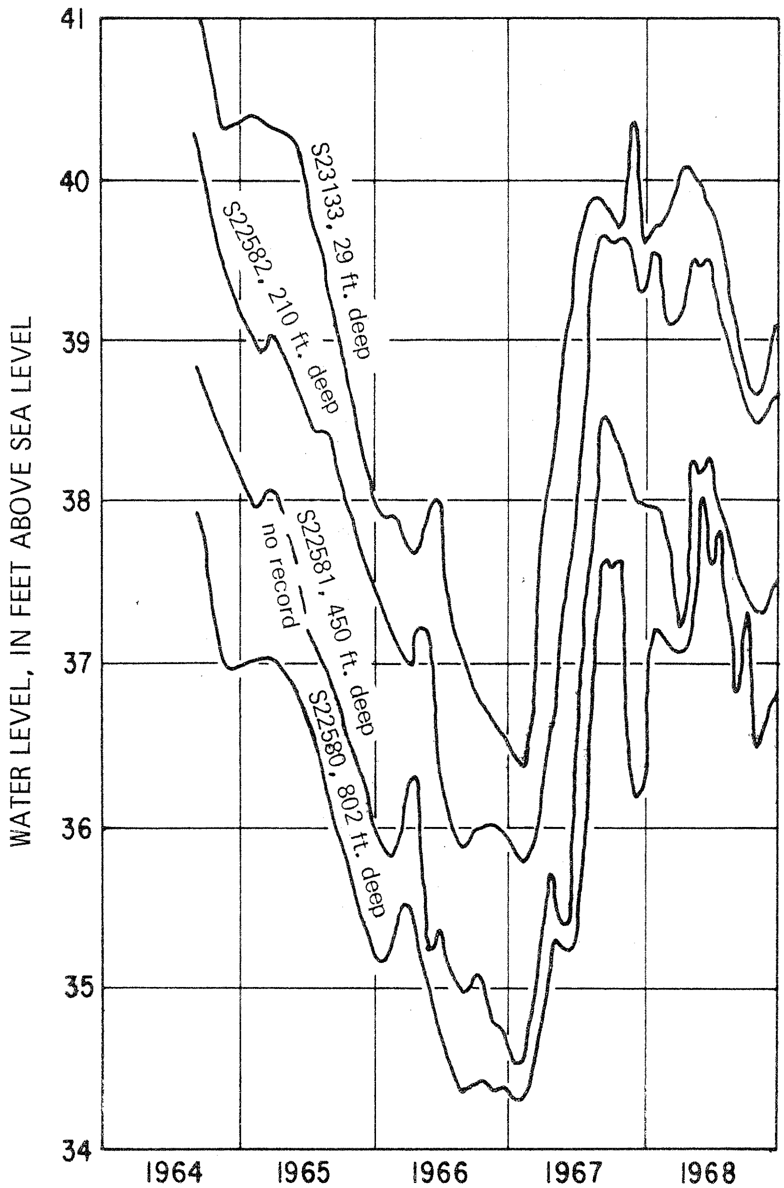

Figure 3.--Fluctuations of water levels in wells screened in the upper glacial aquifer and the Magothy aquifer at Hauppauge, N. Y.

Under natural conditions and in relatively undeveloped areas of Long Island, the water table fluctuates over a range of several feet during the year. Under such conditions, the water table has a rhythmic seasonal pattern; the lowest levels are in late autumn and highest levels are in early spring. This pattern of decline and recovery of the water table reflects the greatest losses of water through evapotranspiration during the growing season and the least such losses between growing seasons. The hydrologic systems in such undeveloped areas are in equilibrium, with inflow balancing outflow. However, if large amounts of water are continually pumped out of a ground-water system, the water table declines until equilibrium is reestablished at a lower level, reflecting a loss of ground water from storage and decreased subsurface and stream outflow from the system.

In 1903, the altitude of the water table along the main ground-water divide of the mid-island area was about 100 feet above sea level near the western end of the project area; it was about 50 feet above sea level in the central part, and about 65 feet above sea level near the eastern end (Veatch and others, 1906, pl. 12). Water-table maps for the years 1943 and 1951, prepared by Jacob (1945, pl. 1) and Lusczynski and Johnson (1951, pls. 1-2), show that the altitude of the water table along the divide near the western end, middle, and eastern end of the project area was about 80, 45, and 65 feet above sea level, respectively. In 1968, the altitude of the water table along the ground-water divide in the mid-island area (pl. 6) was about 70 feet above sea level at the extreme western end, about 40 feet above sea level in the central part, and about 65 feet above sea level at the northeastern corner of the project area. Thus, from 1903 to 1968, the water table along the ground-water divide declined about 30 feet at the western end, and about 10 feet in the central area; no significant net decline of the water table occurred at the extreme northeastern end of the main ground-water divide from 1903 to 1968 (fig. 4).

Water-table fluctuations at the western end and near the eastern end of the ground-water divide in the mid-island area are shown in the hydrographs of wells N1246 and S1812, respectively (fig. 5). Well N1246 (not shown in pl. 1) is in Nassau County just to the west of the Suffolk-Nassau boundary, and just south of the Long Island Expressway. The hydrographs show no significant long-term change in level from 1945 to 1963. The earliest records of water levels in these wells (from 1940 at N1246, and from 1937 at S1812) show about the same range of fluctuations as that in the 1945-63 period. The decline shown in both hydrographs from 1963-66 is attributed mainly to drought conditions in 1962-66. Partial recovery from drought conditions is indicated for the years 1967-68. (See Cohen and others, 1969, p. 7, 10, and 17.)

Most of the decline of the water table in the mid-island area from 1903 to 1968 probably occurred in the last two decades. The 1962-66 drought conditions apparently caused about half the decline (fig. 5). Most of the remainder of the decline was caused by several factors related to urbanization, most notably increased ground-water pumpage for public-supply use and decreased recharge related to the construction of impervious surfaces such as streets and highways. Accordingly, the largest decline occurred in the western part of the area, where population increased most rapidly in the past decade or so. Many public-supply wells have been installed in the eastern half of the mid-island area (as well as in other parts of the area) in the past few years, and as pumpage continues to increase, additional water-level declines throughout the entire project area are to be expected.

The large loss of ground water in storage in the mid-island area can only be approximately computed. A volume of aquifer material on the order of 0.24 cubic mile was dewatered between 1903 and 1968. Assuming that the specific yield of the aquifer material ranges from 20 to 25 percent, the estimated total loss of ground water in storage during that period was roughly 50-70 billion gallons. This amount is small compared to the estimated total ground water in storage beneath the mid-island area. This storage consists of approximately 4.5 trillion gallons, of which about 2.5 trillion is in the upper glacial and Magothy aquifers, and about 2 trillion is in the Lloyd aquifer.

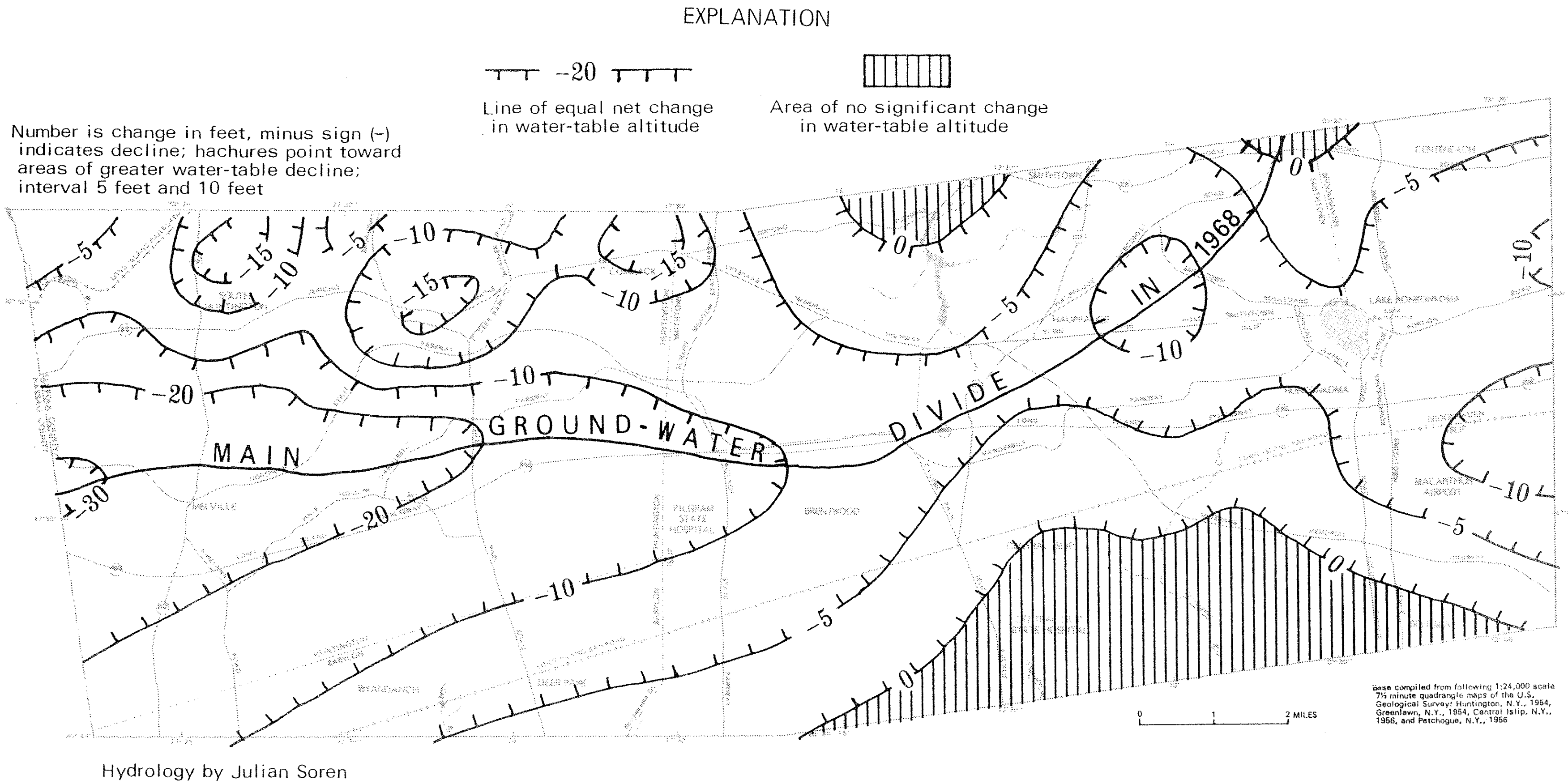

Figure 4.--Mid-island area showing approximate net change in altitude of the water table from 1903 to 1968. (Change in water levels based on data from Veatch and others, 1906, pl. 12, and pl. 6 of this report.)

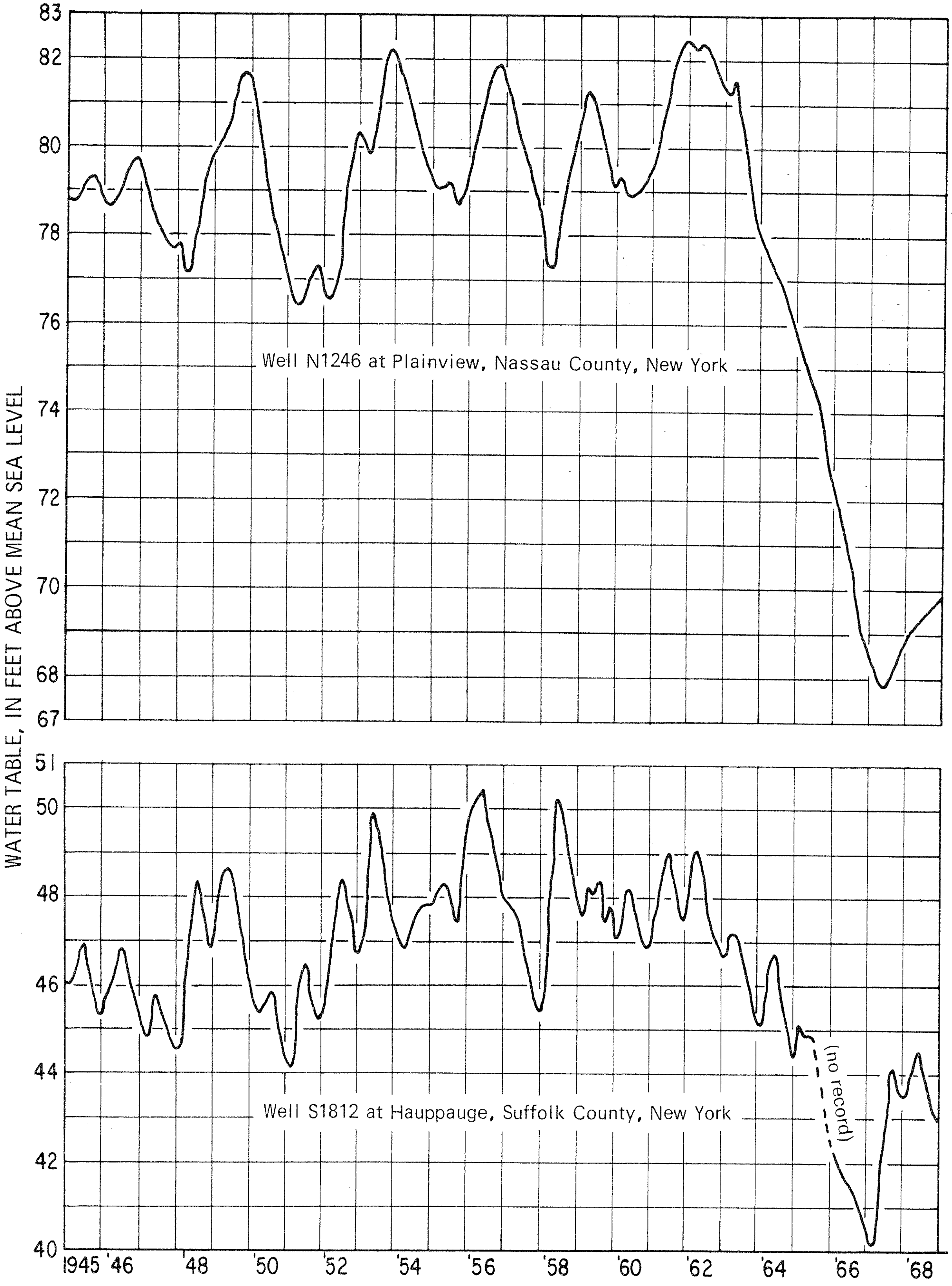

Figure 5.--Water-table fluctuations in the vicinity of the main ground-water divide, 1945-68.

UTILIZATION OF GROUND WATER

Ground water is presently the only source of fresh water in Suffolk County, and the estimated per capita use of water is on the order of 100 gpd. In addition to domestic use, ground water also is used for agricultural and industrial purposes, especially for air-conditioning and cooling.

In the mid-island area, pumpage in 1968 for all purposes was about 33 mgd, which was about 2.5 times the pumpage in 1958. Pumpage data for Suffolk County prior to 1958 are not adequate to estimate pumpage in the mid-island area before that date. However, total pumpage in the county was about 43 mgd in 1950 and about 138 mgd in 1968. Because population growth in western Suffolk was much greater than elsewhere in the county, pumpage in the mid-island area in 1968 doubtless was at least three times greater than pumpage in 1950.

Most of the pumpage in the mid-island area is for public-supply use, and most of this water is supplied by private and public water companies including: Suffolk County Water Authority, Greenlawn Water District, South Huntington Water District, Dix Hills Water District, Brentwood Water District, and Parsnip Pond Water Co. Institutions that pump large amounts of water are: Pilgrim State Hospital, in Brentwood; Central Islip State Hospital, in Central Islip; and the New York State Department of Mental Hygiene School and Hospital, in Melville.

Many homes, especially those near the ground-water divide, have private small-capacity wells. However, the amount of water pumped from such wells is small compared to the total amount pumped by the water companies and the large institutions.

The major ground-water pumpage in the mid-island area in 1958 and 1968 was as follows:

Water company or institution	Average pumpage (mgd) 1/ 1958	1968
Suffolk County Water Authority	3.2 2/	17.9
Greenlawn Water District	1.	1.5
South Huntington Water District	1.9	2.6
Pilgrim State Hospital	1.8	2.2
Brentwood Water District	.5	2
Dix Hills Water District	.1	1.9
Central Islip State Hospital	1.4	1.6
Others (including private homes and agricultural users)	3.5	3.5
Totals (rounded)	13	33

1/ Information furnished by the N.Y. Water Resources Commission and the Greenlawn Water District.

2/ Includes pumpage of several small private water companies acquired by the Authority after 1958.

QUALITY OF GROUND WATER

Most of the ground water pumped to 1968 in the mid-island area readily met the drinking-water standards established by the U.S. Public Health Service (U.S. Department of Health, Education, and Welfare, 1962, p. 7). Water from all the aquifers in the area is generally soft, low in dissolved-solids content, and slightly acidic; and the ground-water temperature is suitable for air-conditioning and cooling uses. Analyses of water samples obtained from 1964 to 1969 are listed in table 2. These analyses were made mainly in conjunction with the exploratory test-drilling program. Hundreds of other analyses of ground water from the area were examined, and were found to be very similar to most of the analyses listed in table 2.

The constituents and characteristics that are of greatest concern to water users in the mid-island area are: iron, manganese, synthetic detergents, nitrate, hardness, dissolved solids, acidity, and temperature. These items are discussed under the separate headings that follow.

Iron

Excessive iron in water causes brownish and rusty staining and discolrations of utensils and laundered clothing, and causes an unpleasant (bitter or astringent) taste in water and in beverages (such as coffee and tea). Concentrations of iron above 0.3 mg/l (milligrams per liter) in drinking water are considered excessive by the U.S. Public Health Service. However, iron concentrations several times greater than 0.3 mg/l are not injurious to health, and such concentrations are not commonly found in the ground water in the mid-island area. The iron concentration in 25 of the 33 analyses in table 2 is less than 0.3 mg/l; the highest iron concentration is 1.7 mg/l. Iron content generally is lowest in the water from the upper glacial aquifer, and water from this aquifer in the mid-island area rarely has more than 0.3 mg/l of iron. Water from the Magothy and Lloyd aquifers frequently contains iron in excess of 0.3 mg/l. Pyrite (iron sulfide) and to a lesser degree siderite (iron carbonate), which are common in the aquifers, probably are the sources of much of the iron in the water from the Magothy and Lloyd aquifers.

Manganese

Manganese commonly is closely associated with iron. Manganese concentrations of more than 0.05 mg/l are considered excessive by the U.S. Public Health Service, generally for the same reasons as for iron. Concentrations of manganese in ground water in the mid-island area are generally well below the recommended maximum limit. Only five analyses in table 2 show more than 0.05 mg/l; the highest concentration of manganese is 0.2 mg/l (sample S22581), and the other four analyses do not show a manganese concentration of more than 0.11 mg/l (samples S13620, 24771, 24774, and 24778).

Synthetic Detergents

Synthetic detergents (commonly referred to as MBAS) in the ground water have caused considerable concern in parts of Long Island (Perlmutter, and others, 1964, p. 170) because their presence indicates pollution by cesspool effluent or other waste water. The U.S. Public Health Service has recommended that concentration of synthetic detergents in water should not exceed 0.5 mg/l. None of the analyses in table 2, or other analyses of water from the area that were examined by the author, show excessive amounts of synthetic detergents. The highest concentration, 0.17 mg/l, was in water from well S4184, in the Smithtown area (not shown in table 2; location shown in pl. 1).

Nitrate

The presence of large amounts of nitrate in ground water may indicate pollution by sewage or fertilizers. High concentrations of nitrate can be harmful to infants. Therefore, the U.S. Public Health Service has recommended 45 mg/l as the maximum allowable concentration of nitrate (as NO_3) in drinking water. Ground water from the mid-island area is commonly very

low in nitrate. Of all the analyses studied in the mid-island area, only one analysis showed a concentration of as much as 45 mg/l (table 2, S29778). This sample was from a well in a farmed area, and the nitrate is attributed to downward leaching of fertilizer components. Water from a slightly deeper well at the same site had a nitrate concentration of 20 mg/l (table 2, S29776B), and three deeper wells at the same site showed greatly lower nitrate concentrations with increasing depths of the wells (table 2, S29776, 29776A, and 29777). None of the other analyses of ground water in the mid-island area had more than about 11 mg/l of nitrate, and most analyses showed less than 5 mg/l.

Hardness

Hardness of water is a quality that is commonly associated with the lathering action of soap; soap lathers well with "soft" water, and lathers poorly with "hard" water. In the mid-island area, hardness of water is largely related to the amounts of calcium and magnesium it contains. The classification adopted by the U.S. Geological Survey for softness or hardness of water is as follows: soft, 0-60 mg/l; moderately hard, 61-120 mg/l; hard, from 121-180 mg/l; and very hard, over 180 mg/l (Durfor and Becker, 1964).

Analyses of water from only three wells in the mid-island area showed hardness of more than 60 mg/l, the greatest being 88 mg/l. These analyses were of water from wells, S4184 and S11891, in the Smithtown area, and S19565, in the Central Islip area (not shown in table 2; locations shown in pl. 1). The three wells are screened in the upper glacial aquifer. The greatest hardness given in table 2 is 57 mg/l, and it is for water from the shallowest of five wells screened in the Magothy aquifer at the westernmost test-drilling site (S29778) in Melville. The water table is in the Magothy aquifer at this site, and the overlying glacial deposits are unsaturated. The hardness of most samples of ground water in the mid-island area was less than 20 mg/l, and water containing substantially more than this amount probably has been contaminated with fertilizer components or cesspool effluent.

Dissolved Solids

Excessive dissolved solids in water leave undesirable incrustations in cooking utensils and steam boilers, and depending upon the amounts and types of dissolved solids present, may be otherwise undesirable. All the ground-water analyses from the mid-island area show dissolved-solids concentrations to be much less than the maximum of 500 mg/l generally recommended by the U.S. Public Health Service. A few of the analyses showed slightly more than 100 mg/l, but the majority of analyses showed less than 50 mg/l. Of the 33 analyses in table 2, only one (S29778) showed dissolved solids of more than 100 mg/l, and only four (S13620, 22578, 29776B, and 29778) showed more than 50 mg/l. A dissolved-solids content of more than 50 mg/l in the ground water of the mid-island area is probably indicative of contamination.

Acidity

Acidity or alkalinity of the ground water in the mid-island area is indicated by its pH (hydrogen-ion concentration). A pH of 7 indicates neutrality; pH lower than 7 indicates acidity, with acidity increasing as pH decreases. A pH greater than 7 indicates alkalinity, with alkalinity increasing as pH increases. Excessive acidity or alkalinity causes water to be corrosive to plumbing and utensils, and either characteristic is therefore undesirable.

Only three of the ground-water analyses from the mid-island area showed pH's of 7 or more; the highest of these was 7.2. The highest pH shown in table 2 is 7.0 (S33380). Consequently, alkalinity is not a problem in the mid-island area. Most of the analyses showed pH determinations lower than 6.5, ranging as low as 5.3. The U.S. Public Health Service has set no standards on pH, stating that drinking water ***"should not be excessively corrosive to the water supply system."*** Acidity of about pH 6.5 or less makes water slightly to highly corrosive. In the project area, where the pH of natural ground water used for public supply is lower than about 6.5, the pH is generally raised by chemical treatment before entering distribution mains.

Temperature

The temperature of the ground water in the mid-island area is about the same as the mean annual air temperature, and the water is suitable for use in air-conditioning and cooling systems. The temperatures of ground water in table 2 range from 10 to 14°C (50 to 58°F). In the mid-island area, ground-water temperatures generally range from 10 to 12°C (50 to 54°F) from land surface to about 600 feet, and from 12 to 14°C (54 to 58°F) from about 600 feet to the greatest depth sampled (1,300 feet). The increasing ground-water temperature with depth is a natural phenomenon, and the geohydrothermal gradient in the ground-water reservoir of the mid-island area is about 1°C (0.6°F) per 100 feet of depth.

Table 2.--Selected chemical analyses of ground water from the mid-island area of western Suffolk County, N. Y.

(Aquifers: G, upper glacial; M, Magothy; L, Lloyd)

(Analyses by U.S. Geological Survey)

Well number	Location	Owner	Depth (feet below land surface)	Aquifer	Date of sample	Chemical constituents (milligrams per liter)																Physical characteristics (in units indicated)			Remarks
						Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue at 180°C)	Hardness (as $CaCO_3$)	MBAS 1/	Specific conductance (micromhos at 25°C)	pH	Temperature (°C)	
S13620	Lake Ronkonkoma	Suffolk County Water Authority	130	G	April 14, 1969	12	0.01	0.11	7.2	2.1	8.6	1.1	22	--	3.6	10.0	0.0	16.0	59	26	0.05	111	6.3	11	At same site as S33379-80.
S21009	Central Islip	Central Islip State Hospital	432	M	July 27, 1966	11	.10	.00	3.2	.7	1.8	.3	6	0	2.7	4.0	.2	.1	30	11	--	45	6.2	--	
S22577	Hauppauge	U.S.G.S.	734	M	August 11, 1964	8.7	.15	--	5.6	2.9	4.4	.9	32	0	3.6	4.1	.3	.0	47	26	--	70	6.9	13	
S22578	do.	do.	402	M	August 11, 1964	12	.41	--	5.9	2.8	4.4	.5	35	0	2.6	3.5	.2	.0	53	26	--	72	7.0	11	
S22579	do.	do.	210	G	August 12, 1964	12	.56	--	5.4	2.0	4.3	.4	30	0	3.6	2.7	.1	.6	47	22	.0	65	6.9	11	
S22580	do.	do.	802	M	July 28, 1964	6.8	.19	.00	1.5	.1	3.8	.4	8	0	2.4	4.0	.0	.0	24	4	--	32	6.1	12	
S22580A	do.	do.	642	M	May 14, 1964	12	.55	.00	2.8	1.0	3.8	.9	16	0	1.0	4.0	.1	.0	39	11	--	46	6.3	12	Temporary well installation for obtaining water sample only; well subsequently removed.
S22580B	do.	do.	296	M	May 28, 1964	15	.16	.02	3.2	1.0	4.2	1.0	20	0	1.2	4.2	.1	.1	48	12	--	47	6.8	11	Do.
S22581	do.	do.	450	M	July 23, 1964	13	1.6	.2	3.3	1.0	4.8	.3	18	0	2.8	4.0	.2	.1	40	12	--	51	6.5	13	
S23133	do.	do.	29	G	August 11, 1964	6.8	.31	--	5.0	3.3	4.6	.8	5	0	12	10	.1	6.0	50	26	.0	83	5.9	10	At same site as S22577-79.
S23631	Smithtown	Suffolk County Water Authority	595	M	July 26, 1966	9.3	.45	.00	3.3	1.6	4.5	.3	19	0	2.9	3.7	.0	.1	36	14	--	47	6.9	12	
S24769	Brentwood	U.S.G.S.	810	M	August 12, 1965	6.2	.27	.01	1.5	.6	3.8	.5	7	0	2.4	4.4	.0	.0	20	6	--	33	6.0	12	
S24769A	do.	do.	683	M	July 9, 1965	6.6	.10	.03	1.6	.5	3.9	.4	11	0	.2	4.5	.0	1.1	24	6	--	38	6.5	13	Temporary well installation for obtaining water sample only; well subsequently removed.
S24769B	do.	do.	220	M	August 6, 1965	9.1	.15	.05	1.4	.6	3.3	.3	7	0	.4	3.6	.0	.0	17	6	--	26	6.4	11	Do.
S24770	do.	do.	434	M	August 10, 1965	6.4	.14	.01	2.1	.2	3.0	.3	8	0	2.0	3.5	.0	.1	16	6	--	30	6.2	12	
S24771	do.	do.	125	G	December 12, 1965	8.6	.21	.08	.5	.7	4.0	.2	4	0	2.1	5.8	.1	.0	32	4	--	26	5.8	10	
S24772	do.	do.	838	M	October 13, 1965	6.4	.24	.02	1.0	1.3	3.8	.3	10	0	1.6	5.0	.1	.2	25	8	--	33	6.3	12	
S24772A	do.	do.	688	M	September 24, 1965	7.5	1.7	.02	2.0	1.0	2.9	.2	10	0	2.1	4.0	.1	.4	27	9	--	33	6.6	12	Temporary well installation for obtaining water sample only; well subsequently removed.
S24772B	do.	do.	238	M	October 19, 1965	12	.15	.04	2.6	.8	4.7	.2	14	0	2.7	4.0	.1	.0	34	10	--	39	6.7	11	Do.

1/ Methylene-blue active substances, primarily synthetic detergents.

Table 2.--Selected chemical analyses of ground water from the mid-island area of western Suffolk County, N. Y. (continued)

(Aquifers: G, upper glacial; M, Magothy; L, Lloyd)

(Analyses by U.S. Geological Survey

						Chemical constituents (milligrams per liter)																Physical characteristics (in units indicated)			
Well number	Location	Owner	Depth (feet below land surface)	Aquifer	Date of sample	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue at 180°C)	Hardness (as $CaCO_3$)	MBAS 1/	Specific conductance (micromhos at 25°C)	pH	Temperature (°C)	Remarks
S24773	Brentwood	U.S.G.S.	422	M	November 11, 1965	15	0.17	0.05	2.0	0.2	3.5	0.1	9	0	2.1	4.0	0.1	0.0	28	6	--	30	6.3	11	
S24774	do.	do.	110	G	November 19, 1965	9.4	.13	.06	2.3	1.1	5.1	1.2	11	0	5.4	5.1	.0	.5	44	10	--	47	6.3	10	
S27739	Wyandanch	do.	850	M	May 16, 1966	6.6	.02	.00	4.0	.3	2.8	.4	4	0	2.6	4.3	.0	.0	19	2	0.0	24	5.8	12	
S27739A	do.	do.	658	M	May 18, 1966	--	.01	--	--	--	--	--	6	0	1.4	2.5	--	--	--	3	--	44	6.1	12	Temporary well installation for obtaining water sample only; well subsequently removed.
S27739B	do.	do.	296	M	June 13, 1966	8.9	.08	.01	1.6	.7	4.2	.5	8	0	1.0	5.8	.1	2.1	31	7	--	36	6.1	11	Do.
S27740	do.	do.	429	M	June 7, 1966	5.8	.11	.0	.4	.2	3.2	.4	4	0	2.0	4.8	.1	.1	16	2	.0	25	5.7	11	
S27441	do.	do.	176	M	June 24, 1966	6.7	.02	.00	.4	.2	3.6	.4	4	0	2.0	4.5	.0	.2	21	2	--	29	6.0	11	
S29776	Melville	do.	720	M	April 19, 1967	.7	.06	.05	.4	.2	2.9	.5	5	0	3.2	4.0	.1	.0	27	2	.02	25	5.8	12	
S29776A	do.	do.	563	M	March 15, 1967	6.0	.13	.03	.7	.2	2.7	.2	3	0	.2	2.0	.0	.1	21	2	.02	23	5.5	11	Temporary well installation for obtaining water sample only; well subsequently removed.
S29776B	do.	do.	283	M	April 11, 1967	.1	.03	.05	4.8	1.8	7.5	.9	5	0	.4	12	.0	20	58	20	.02	91	6.0	11	Do.
S29777	do.	do.	397	M	April 10, 1967	.1	.06	.04	.5	.2	3.6	.3	5	0	.6	4.0	.0	2.4	25	2	.02	27	6.0	10	
S29778	do.	do.	168	M	April 21, 1967	7.1	.01	.06	7.8	9.1	10	.9	5	0	8.1	18	.1	45	135	57	.10	193	5.5	11	
S33379	Lake Ronkonkoma	do.	1,300	L	September 20, 1968	7.2	1.5	.03	.8	1.4	3.7	1.8	11	0	4.9	4.0	.0	.0	38	8	.01	42	6.7	14	
S33380	do.	do.	850	M	October 3, 1968	.11	.39	.01	2.8	1.2	4.1	.4	16	0	1.9	4.0	.0	.0	46	12	.01	41	7.0	12	

1/ Methylene-blue active substances, primarily synthetic detergents.

POTENTIAL DEVELOPMENT OF GROUND WATER IN THE MID-ISLAND AREA

by
Philip Cohen

Some of the major questions commonly posed by those concerned with the development of ground water in the mid-island area are: (a) how much water of suitable chemical quality can be withdrawn from individual wells and from the entire ground-water reservoir in the area and for how long a period, and (b) what will be the effects of such withdrawals? Although the information developed as part of the current investigation cannot directly yield precise answers to these questions, that information plus additional available data can supply some insight into the answers to these and related questions.

YIELDS OF INDIVIDUAL WELLS

The yield, or the amount of water withdrawn from individual wells ranges in the mid-island area from a few gallons per minute to about 1,700 gpm. Numerous factors affect the yield of a well, and some of these factors are reviewed briefly in the following paragraphs to develop the background needed to assess the possible yield of future wells in the mid-island area.

The major factors that affect the yield of an individual well are (a) the permeability of the material tapped by the well, (b) the length (and to a lesser extent the diameter) of the well screen, (c) the so-called efficiency of the well, (d) the "lift" (the distance the water is lifted from the pumping level in the well to the land surface), (e) the duration of pumping, and (f) mechanical aspects of the pumping equipment.

McClymonds and Franke (written communication, 1969) have shown recently that, on the average, the yields of wells on Long Island can be approximately related to the permeability of the material adjacent to the well screen by the following equation:

$$Q \cong \frac{Psl}{2,000} \tag{1}$$

where,

Q = yield of the well, in gpm;

P = average permeability of the material adjacent to the well screen, in gpd per sq ft;

s = drawdown in the well, in ft; and

l = length of the well screen, in ft.

It follows from this equation that, on the average, the specific capacity of a well $\frac{Q}{s}$ on Long Island is approximately related to the average permeability of the material adjacent to the well screen and length of well screen as follows:

$$\frac{Q}{s} \cong \frac{Pl}{2,000} \tag{2}$$

and that the specific capacity divided by the length of the well screen is approximately related to permeability as follows:

$$\frac{Q}{sl} \cong \frac{P}{2,000} \tag{3}$$

The value $\frac{Q}{sl}$ is herein termed the unit specific capacity, and is expressed in gpm per sq ft.

Pertinent performance data for nearly all the public-supply wells in the mid-island area are listed in table 3. The reported yields of these wells range from about 500 to 1,700 gpm; the specific capacities range from about 5 to 170 gpm per ft; and the unit specific capacities range from 0.2 to 4.1 gpm per sq ft. Virtually all these data were obtained from drillers' acceptance tests, and the present production rates may be considerably different from those shown in the table. In most cases, significantly different rates would largely be related to differences in present pump capacity compared to the pump capacity during the acceptance test. For example, if well S8251, which reportedly yielded 1,000 gpm with 70 feet of drawdown after 4 hours of pumping, were equipped with a large enough pump, it might yield as much as 2,000 gpm, and if the well were highly "efficient", the expected drawdown would be no more than about twice that shown in the table, after 4 hours of pumping. In this context, well efficiency is mainly related to the adequacy of well construction and development, and on Long Island, most of the large-capacity wells constructed in the past decade or two are highly efficient. The specific capacity and the unit specific capacity of a highly efficient well tends to remain nearly constant over a wide range of pumping rates.

In all pumping wells the water level in the well declines as a function of time. Accordingly, the specific capacity and the unit specific capacity also decrease with increasing pumping time. As a result, because most large-capacity wells on Long Island are equipped with constant speed pumps, the yields of these wells decrease as water levels in the wells decline. More than 95 percent of the decline in the water level in most wells on Long Island commonly occurs in the first hour or two after pumping begins. For example, the results of two pumping tests using an experimental well (N7884) at Bay Park in Nassau County (about 15 miles southwest of the mid-island area) are shown in figure 6. After 100 minutes of pumping at a rate of 195 gpm, the water level in the well had declined about 5.8 feet, and after 3,000 minutes (about 2 days) the total decline was 6.0 feet. In a second test, the well was pumped at a rate of 400 gpm, and the decline in the water level was 11.8 feet after 100 minutes and 12.2 feet after 3,000 minutes.

The graphs in figure 6 (and additional test data) indicate that the well at Bay Park is highly efficient. The specific capacities of the well after several hours of pumping were nearly identical during each test -- about 32.5 gpm per ft during the first test and about 32.8 gpm per ft during the second test. In an earlier test, in which the well was pumped at about 3,500 gpm, the specific capacity was also about 33 gpm per ft.

The moderately wide range in specific-capacity values listed in table 3 is caused by many factors; probably the two most significant are as indicated by equation 2, the permeability of the materials adjacent to the well screens and the lengths of the screens. Differences in well efficiency probably is the next most significant factor, and, in accordance with the previous discussion, differences in the length of the pumping tests probably are of little significance.

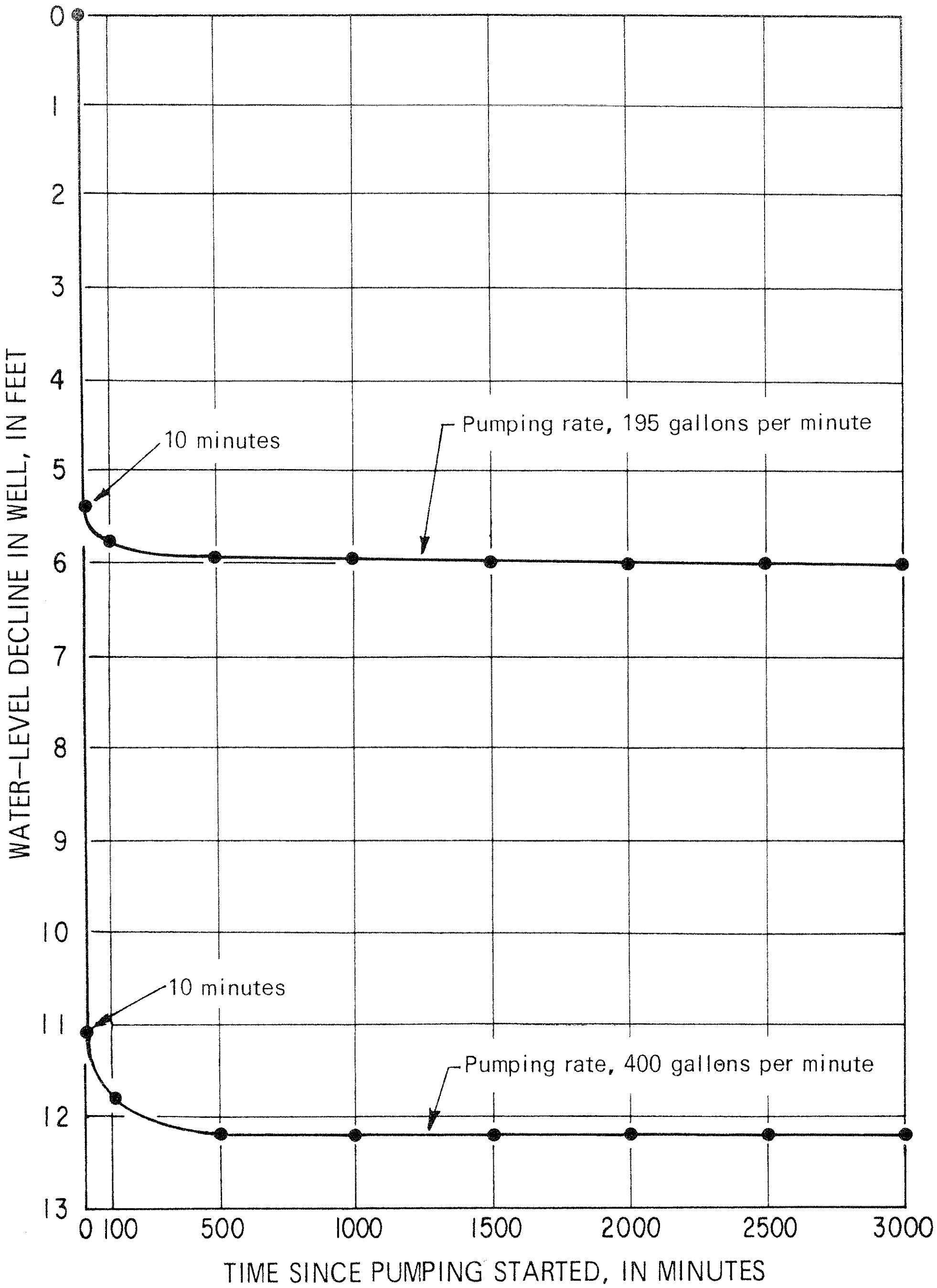

Figure 6.--Drawdown in a pumping well (N7884) at Bay Park, Nassau County, N. Y.

Table 3.--Reported performance of public-supply wells in the mid-island area, Suffolk County, N. Y.

(Well data provided by N. Y. State Conservation Department, Division of Water Resources, Westbury, N. Y.

Well number	Screen length (feet)	Screen diameter (inches)	Discharge 1/ (gpm)	Drawdown (feet)	Length of test (hours)	Specific capacity (gpm per ft)	Unit specific capacity 2/ (gpm per sq ft)
			UPPER GLACIAL AQUIFER				
S 203	21	10	700	56	17	13	0.6
S 4184	26	12	800	25	--	32	1.2
S 11810	27	12	500	85	--	6	.2
S 11891	22	12	1,000	46	8	22	1.0
S 12143	40	12	1,400	24	8	58	1.5
S 13534	31	16	1,500	27	8	56	1.8
S 13558	38	12	900	18	40	50	1.3
S 15500	33	16	1,500	11	2	136	4.1
S 15501	36	16	1,500	11	2	136	3.8
S 15898	32	15	1,700	26	--	65	2.0
S 16049	62	12	1,300	14	8	93	1.5
S 16124	20	0	600	9	2	67	3.4
S 16175	36	16	1,500	27	8	56	1.6
S 16176	36	16	1,500	22	8	68	1.9
S 16608	30	10	1,000	13	8	77	2.6
S 18621	57	10	1,400	38	8	37	.6
S 19399	46	16	1,000	13	8	77	1.7
S 19565	36	16	1,400	15	8	93	2.6
S 19584	35	16	1,500	11	8	136	3.9
S 19884	21	12	500	64	5	8	.4
S 19885	21	12	500	92	4	5	.2
S 20045	36	15	1,500	17	8	88	2.4
S 20479	33	16	1,000	10	8	100	3.0
S 21006	62	12	1,200	7	--	171	2.8
S 22171	31	12	500	16	4	31	1.0
S 22494	36	16	1,500	15	8	100	2.8
S 22547	27	16	1,000	39	8	26	1.0
S 22711	37	16	1,200	24	8	50	1.4
S 23522	60	12	1,400	9	3	156	2.6
S 23523	113	12	1,400	16	2	88	.8
S 24047	35	16	1,200	12	7	100	2.9
S 29962	61	12	1,500	33	8	45	.7
S 30117	45	16	900	19	8	47	1.0
S 30118	51	16	1,000	14	8	71	1.4
S 30234	35	15	1,000	8	8	125	3.6
Average	39	14	--	--	8	71	1.9

1/ Rounded.
2/ See section, "Yields of Individual Wells."

Table 3.--Reported performance of public-supply wells in the mid-island area, Suffolk County, N. Y. (continued)

(Well data provided by N. Y. State Conservation Department, Division of Water Resources, Westbury, N. Y.)

Well number	Screen length (feet)	Screen diameter (inches)	Discharge 1/ (gpm)	Drawdown (feet)	Length of tes (hours)	Specific capacity (gpm per ft)	Unit specific capacity 2/ (gpm per sq ft)
				MAGOTHY AQUIFER			
S 8251	53	12	1,000	70	4	14	0.3
S 13876	52	12	1,500	40	8	38	.7
S 14326	61	12	1,400	42	4	33	.5
S 18058	62	12	1,200	14	8	86	1.4
S 18261	55	10	1,500	46	8	33	.6
S 18566	61	10	1,300	68	8	19	.3
S 19057	72	12	1,600	28	8	57	.8
S 20057	30	10	500	17	4	29	1.0
S 20300	31	10	600	27	4	22	.7
S 20318	60	12	1,200	33	6	36	.6
S 20369	50	12	1,400	53	8	26	.5
S 20689	80	12	1,200	29	8	41	.5
S 22362	68	12	1,500	46	8	33	.5
S 22471	69	12	1,500	62	8	24	.3
S 22548	72	12	1,500	51	8	29	.4
S 23046	55	10	1,500	37	8	41	.7
S 23183	74	10	1,200	26	8	46	.6
S 23445	64	10	1,200	26	8	46	.7
S 23631	101	12	1,500	40	8	38	.4
S 23715	80	12	1,200	22	--	55	.7
S 23832	70	10	1,200	51	8	24	.3
S 23999	71	12	1,200	55	8	22	.3
S 24846	56	12	1,700	51	40	33	.6
S 25617	81	10	1,200	22	8	55	.7
S 26247	72	12	1,600	19	8	84	1.2
S 26248	35	12	1,500	42	5	36	1.0
S 27533	83	10	1,500	34	8	44	.5
S 29852	91	12	1,200	27	8	44	.5
S 30007	70	12	1,400	35	8	40	.6
S 30008	60	12	1,400	22	--	64	1.0
S 30506	62	12	1,200	30	8	40	.6
S 31104	63	10	1,500	36	8	42	.7
S 31624	80	12	1,200	33	7	36	.5
S 32412	70	12	1,400	38	8	37	.5
Average	65	11	--	--	8	40	0.6

1/ Rounded.
2/ See section, "Yields of Individual Wells."

The average unit specific-capacity value of wells screened in the upper glacial aquifer is 1.9 gpm per sq ft; for wells screened in the Magothy aquifer the average is 0.6 gpm per sq ft (table 3). Accordingly, from equation 3, the estimated average permeability of the beds of the upper glacial aquifer tapped by the public-supply wells in the mid-island area is 3,800 gpd per sq ft and that for the Magothy aquifer is 1,200 gpd per sq ft. It is important to note that these estimates do not apply to all the materials in the aquifers, but only to the most permeable zones, inasmuch as, on the average, these are the zones in which the screens of wells are commonly placed.

At each of the sites at which test wells were drilled as part of this study, the average permeability of at least 50 feet of material in one or both of the major aquifers probably is equal to or greater than the estimated average permeability values developed in the preceding paragraph. Accordingly, if an adequately constructed well having a screen 50 feet in length was installed at each site, the expected average specific capacity of these wells would be roughly 30 to 95 gpm per ft of drawdown. Thus, if these wells were suitably equipped, they would be expected to yield anywhere from about 1,500 to as much as about 4,800 gpm with drawdowns of about 50 feet. Greater yields without significantly larger drawdowns in the wells probably could be obtained by using longer screens and larger pumps. Moreover, if larger drawdowns are acceptable, still larger yields could be attained if the wells were equipped with large enough pumps.

GROSS GROUND-WATER WITHDRAWALS

SAFE YIELD

Before considering possible future ground-water withdrawals in the mid-island area, the concept of "safe yield" is reviewed briefly because many people involved in the development and management of Long Island's ground water commonly include that concept in their considerations, especially those considerations involving long-term, gross ground-water withdrawals.

One of the most broadly applicable and useful definitions of "safe yield" was developed by Todd (1959, p. 200-214). He defined the term as follows: "The safe yield of a ground water basin is the amount of water which can be withdrawn from it annually without producing an undesired result." (p. 200). As a consequence of this definition and of the so-called hydrologic-budget concept, the writer concluded (Cohen and others, 1968, p. 92) that, "***the safe yield of the ground-water reservoir, for all of Long Island or for subareas on the island, can range between large limits depending upon future management decisions regarding (a) the undesired results (hydraulic, water-quality, economic, and other) that are to be avoided, (b) the amount of natural ground-water discharge that is salvaged, and (c) the amount of additional ground-water recharge (natural or artificial) that is induced." In other words, it is impossible to assign a single value to the safe yield of the ground-water reservoir beneath the mid-island area without precisely defining all the undesired results both in and beyond the area, and without knowing which of an almost limitless number of possible alternative water-management and water-conservation plans ultimately will be adopted.

POSSIBLE FUTURE WITHDRAWALS

As previously stated, gross pumpage in the mid-island area in 1968 averaged about 33 mgd. That amount of pumpage, plus the pumpage during preceding years, plus the effects of reduced recharge related to the 1962-66 drought, were mainly responsible for the previously described decrease of ground water in storage in the area.

Ground-water withdrawals could be increased substantially in the mid-island area by increasing yields from existing wells, by constructing additional wells in the area, or both. For example, from the standpoint of the hydrologic character of the underlying aquifers, it is highly probable that one well could be constructed in each square mile of the mid-island area that would yield an average of at least 1 mgd. Thus, initially such wells could readily yield 140 mgd. Moreover, for a fairly short period of time, perhaps a decade or so, as much as 280 mgd probably could be withdrawn from the aquifers beneath the mid-island area. However, to the extent that the net withdrawals (the amount permanently removed from the ground-water reservoir) are not compensated for by decreased natural discharge or by increased recharge, ground-water levels will decline regionally, and the yields from the individual wells will decrease because of increased lifts. However, if the increased lifts are compensated for by the installation of larger-capacity pumps, an average yield of 100-200 mgd probably could be sustained in the mid-island area for at least several decades.

Most of the natural ground-water discharge from the mid-island area is by subsurface outflow -- both northward and southward toward the shorelines. If ground-water recharge does not increase significantly, pumpage in the mid-island area and associated declining ground-water levels will cause a decrease in the downward movement of ground water into the deeper artesian aquifers and a decrease in subsurface outflow through these aquifers. Moreover, inasmuch as the downward movement of ground water in the mid-island area is virtually the only natural source of fresh-water recharge to the Magothy and Lloyd aquifers, net ground-water withdrawals from either the upper glacial aquifer or the underlying Magothy aquifer inevitably will result in declining water levels in both the Magothy and Lloyd aquifers throughout virtually all of western Suffolk County.

Insofar as the development of ground water is concerned, two types of pertinent boundaries are found in and near the mid-island area -- political boundaries and hydrologic boundaries. The most important political boundary is that which separates Nassau and Suffolk Counties along the western margin of the mid-island area. Ultimately, intensive net withdrawals in the mid-island area could induce subsurface inflow from Nassau to Suffolk County. (Similarly, the opposite might occur as a result of intensive pumping in eastern Nassau County.) Under these circumstances, significant political as well as hydrologic and economic ramifications may develop.

The pertinent hydrologic boundaries are those that border the fresh ground-water body -- the water table above, the bedrock surface below, and the zones of diffusion between fresh and salty ground water near the shorelines. Under natural conditions, average annual ground-water recharge in and discharge from the mid-island area (roughly 100-140 mgd) were equal,

and the ground-water system was in a state of dynamic equilibrium. Net ground-water withdrawals have disrupted that equilibrium resulting in a decline in the water table and a decrease in the seaward outflow of ground water through the aquifers. This decrease in subsurface outflow has, in turn, caused or will cause a landward movement of the zones of diffusion (so-called salt-water intrusion). To date, regional salt-water intrusion has not been observed in western Suffolk County (perhaps partly because of inadequate data) and such intrusion may in fact be very small or negligible. However, increased net ground-water withdrawals from the mid-island area that are not compensated for by increased recharge will inevitably cause an acceleration of salt-water intrusion -- the rate of which will be approximately proportional to the decrease in subsurface outflow toward the sea.

CONCLUDING STATEMENT

As the population continues to increase in the mid-island area, ground-water withdrawals also will increase to meet the need for additional public-supply water. These withdrawals will result in continued decline of ground-water levels and, ultimately, in salt-water intrusion (first near the shorelines and then progressively landward) unless conservation measures are adopted. Moreover, if most of the domestic and industrial waste water continues to be disposed of through cesspools, septic tanks, and basins, the chemical quality of the ground water will deteriorate progressively.

Public officials in Suffolk County have taken, and are considering, several steps to conserve the quantity and quality of the ground water. Most notably, much of the storm runoff from urban and suburban areas and from highways discharges into drainage basins from which the water seeps downward and ultimately recharges the ground-water reservoir. Moreover, new large housing developments are required to treat domestic sewage and dispose of the waste water in an approved manner, and several such developments are presently returning treated waste water to the ground through basins.

Plans are being considered to construct large-scale sewage collection and disposal systems to protect the quality of the ground water in parts of Suffolk County. If such systems are constructed in the mid-island area and if the treated waste water is discharged into the sea instead of into the ground, ground-water recharge will, of course, decrease. Accordingly, some water managers on Long Island are considering the feasibility of upgrading the quality of treated sewage-plant effluent to meet drinking-water standards and returning that water to the ground (Cohen and others, 1968, p. 97). This and many other water-management alternatives are being reviewed intensively by several agencies in Suffolk County. Whichever alternatives are eventually adopted, present data-collection and data-analysis programs should be intensified to monitor and help evaluate the effects of future water-management decisions.

REFERENCES CITED

Cohen, Philip, Franke, O. L., and Foxworthy, B. L., 1968, An atlas of Long Island's water resources: New York Water Resources Comm. Bull. 62, 117 p.

Cohen, Philip, Franke, O. L., and McClymonds, N. E., 1969, Hydrologic effects of the 1962-66 drought on Long Island, New York: U.S. Geol. Survey Water-Supply Paper 1879-F, 18 p.

Durfor, C. N., and Becker, Edith, 1964, Chemical quality of public water supplies of the United States and Puerto Rico, 1962: U.S. Geol. Survey Hydrol. Inv. Atlas HA-200.

Fuller, M. L., 1914, The geology of Long Island, New York: U.S. Geol. Survey Prof. Paper 82, 223 p.

Isbister, John, 1966, Geology and hydrology of northeastern Nassau County, Long Island, New York: U.S. Geol. Survey Water-Supply Paper 1825, 89 p.

Jacob, C. E., 1945, The water table in the western and central parts of Long Island, New York: New York State Water Power and Control Comm. Bull. GW-12, 24 p.

Johnson, A. H., and Waterman, W. G., 1962, Withdrawal of ground water on Long Island, N. Y.: New York State Water Power and Control Comm. Bull. GW-28, 13 p.

Lubke, E. R., 1964, Hydrogeology of the Huntington-Smithtown area, Suffolk County, New York: U.S. Geol. Survey Water-Supply Paper 1669-D, 68 p.

Lusczynski, N. J., and Johnson, A. H., 1951, The water table in Long Island, New York, in January 1951: New York State Water Power and Control Comm. Bull. GW-27, 28 p.

Lusczynski, N. J., and Swarzenski, W. V., 1966, Salt-water encroachment in southern Nassau and southeastern Queens Counties, Long Island, New York: U.S. Geol. Survey Water-Supply Paper 1613-F, 76 p.

Perlmutter, N. M., and Soren, Julian, 1963, Effects of major water-table changes in Kings and Queens Counties, Long Island, New York: U.S. Geol. Survey Prof. Paper 450-E, p. 136-139.

Perlmutter, N. M., Lieber, Maxim, and Frauenthal, H. L., 1964, Contamination of ground water by detergents in a suburban environment-South Farmingdale area, Long Island, New York: U.S. Geol. Survey Prof. Paper 501-C, p. 170-175.

Perlmutter, N. M., and Todd, Ruth, 1965, Correlation and Foraminifera of the Monmouth Group (Upper Cretaceous), Long Island, New York: U.S. Geol. Survey Prof. Paper 483-I, 24 p., 8 pls.

Pluhowski, E. J., and Kantrowitz, I. H., 1964, Hydrology of the Babylon-Islip area, Suffolk County, Long Island, New York: U.S. Geol. Survey Water-Supply Paper 1768, 119 p.

Roberts, C. M., and Brashears, M. L., Jr., 1945, Record of wells in Suffolk County, N. Y. Supplement 1: New York State Water Power and Control Comm. Bull. GW-9, 155 p.

Soren, Julian, Ground-water and geohydrologic conditions in Queens County, Long Island, New York: U.S. Geol. Survey Water-Supply Paper 2001-A (in press).

Suter, Russell, deLaguna, Wallace, and Perlmutter, N. M., 1949, Mapping of geologic formations and aquifers of Long Island, New York: New York State Water Power and Control Comm. Bull. GW-18, 181 p.

Todd, D. K., 1959, Ground water hydrology: New York, John Wiley and Sons, Inc., 336 p.

U.S. Geological Survey, 1938, Record of wells in Suffolk County, N. Y.: New York State Water Power and Control Comm. Bull. GW-4, 108 p.

U.S. Department of Health, Education and Welfare, 1962, Public Health Service drinking water standards: Public Health Service Pub. no. 956, 61 p.

Veatch, A. C., Slichter, C. S., Bowman, Isaiah, Crosby, W. O., and Horton, R. E., 1906, Underground water resources of Long Island, New York: U.S. Geol. Survey Prof. Paper 44, 385 p.

Warren, M. A., deLaguna, Wallace, and Lusczynski, N. J., 1968, Hydrology of Brookhaven National Laboratory and vicinity, Suffolk County, New York: U.S. Geol. Survey Bull. 1156-C, 127 p.

Table 1.--Geologist's logs of test wells drilled in the mid-island area of western Suffolk County, N. Y.

S22577. U.S. Geological Survey test well, 52 feet north of centerline of Vanderbilt Motor Parkway, 721 feet west of centerline of Parkway Gardens Boulevard, at lat 40°49'02" N, long 73°09'40" W, Town of Islip, N. Y. Standard rotary hole drilled by C. W. Lauman & Co., Inc., August 1964. Altitude of land surface about 61 feet above mean sea level. Log based on examination of core samples, flume (mud-ditch) samples, driller's log, and electrical resistivity and gamma-ray logs.

Description	Thickness (feet)	Depth (feet)
Holocene:		
Top soil and loam	4	4
Pleistocene:		
Upper Pleistocene deposits:		
Sand, fine, light-brown; some granule to small-pebble gravel (up to 1/4-inch diameter).	17	21
Sand, fine to coarse, mostly fine to medium, light-brown, and boulders.	4	25
Sand, fine to very coarse, mostly coarse, light-brown, and granule to small-pebble gravel (up to about 1/4-inch diameter); some medium-pebble gravel (up to about 3/8-inch diameter).	89	114
Smithtown Clay(?):		
Sand, very fine to fine, dark-brown, with much interstital silt; a few thin beds of fine to coarse sand, and a few thin laminae of dark-brown clay.	48	162
Sand, fine to very coarse, mostly coarse, light-brown and granule to medium-pebble gravel (up to about 5/16 inch diameter).	25	187
Sand, fine to very coarse, mostly coarse, light-brown, and granule to very-large-pebble gravel (up to about 2-inch diameter).	17	204
Sand, fine to very coarse, mostly coarse, reddish-brown and granule to very-large-pebble gravel (up to about 2-inch diameter); traces of reddish clay and silt.	61	265
Sand, fine to medium, mostly meduim, light-brown, and granule to large-pebble gravel (up to about 1-inch diameter).	40	305
Sand, fine to very coarse, mostly coarse, light-brown, and granule to very-large-pebble gravel (up to about 2-inch diameter); traces of clay and silt.	51	356

Table 1.--Geologist's logs of test wells drilled in the mid-island area of western Suffolk County, N. Y. (continued)

S22577. (continued)

Description	Thickness (feet)	Depth (feet)
Pleistocene--(continued)		
Upper Pleistocene deposits--(continued)		
Sand, very fine to coarse, mostly medium, light-brown, and granule to large-pebble gravel (up to about 1-inch diameter); many traces of clay and silt.	24	380
Upper Cretaceous:		
Matawan Group - Magothy Formation, undifferentiated:		
Sand, fine to very coarse, mostly medium to coarse, light-gray and light-yellowish-brown; many traces of clay and silt.	36	416
Sand, very fine to fine, light-gray and light-yellowish-gray; many traces of clay and silt.	40	456
Sand, very fine to fine, light-gray with many traces of clay and silt; many thin laminae of lignitic and limonitic silt throughout.	54	510
Clay, mostly silty, light- to medium-gray; some laminae and beds of solid clay up to 1 ft thick; many laminae of limonitic silt.	40	550
Sand, fine to medium, and some coarse sand, light-gray, light-brown, and light-yellowish-gray; many traces of clay and silt throughout.	70	620
Sand, very fine to coarse mostly medium, light-gray, light-yellowish-gray, and light-brown; traces of clay and much silt.	66	686
Sand, very fine to very coarse, mostly medium to coarse, light-gray, and granule to medium-pebble gravel (up to 5/8-inch diameter); many traces of clay and silt; thin laminae of lignitic silt in top foot.	152	838
Raritan Formation:		
Clay member:		
Sand, very fine to medium, mostly fine, and a little coarse sand, light-gray; much interstitial clay and silt.	29	867
Clay, hard, medium-gray and light-gray, laminae of clayey silt in bottom foot.	10	877

Table 1.--Geologist's logs of test wells drilled in the mid-island area of western Suffolk County, N. Y. (continued)

S22577. (continued)

Description	Thickness (feet)	Depth (feet)
Upper Cretaceous--(continued)		
Raritan Formation--(continued)		
Clay member--(continued)		
Clay, silty, medium-gray, abundant flakes of muscovite.	11	888
Silt, clayey, medium-gray, abundant flakes of muscovite; thin laminae of lignitic silt in bottom half.	10	898
Clay, hard, light- to medium-gray.	9	907

S22910T. U.S. Geological Survey test well, 420 feet south of centerline of Long Island Expressway, 45 feet west of centerline of Vanderbilt Motor Parkway, at lat 40°48'28" N, long 73°11'40" W, Central Islip, N. Y. Standard rotary hole drilled by C. W. Lauman & Co., Inc., April 1964. Altitude of land surface about 125 feet above mean sea level. Log based on examination of cores, flume (mud ditch) samples, driller's log, and electric resistivity and gamma-ray logs.

Description	Thickness (feet)	Depth (feet)
Pleistocene:		
Upper Pleistocene deposits:		
Loam, fine to very coarse sand, light-brown, and granule to large-cobble gravel (up to 8-inch diameter).	6	6
Sand, fine to coarse, light-brown, and granule to very-large-pebble gravel (up to 2-inch diameter).	175	181
Smithtown clay(?):		
Sand, medium, some fine sand, light-brown.	20	201
Pleistocene, undifferentiated		
Sand, coarse, light-brown, and gravel, weakly cemented.	9	210
Upper Cretaceous:		
Matawan Group-Magothy Formation, undifferentiated:		
Sand, fine, some medium to coarse sand, gray and light-brown, and thin beds of light-gray clay.	37	247
Clay, gray, and sandy clay.	9	256
Sand, fine, gray and light-brown, and some thin beds of light-gray clay.	44	300

Table 1.--Geologist's logs of test wells drilled in the mid-island area of western Suffolk County, N. Y. (continued)

S22910T. (continued)

Description	Thickness (feet)	Depth (feet)
Upper Cretaceous--(continued)		
Matawan Group-Magothy Formation undifferentiated--(continued)		
Sand, fine, traces of silt, gray, light-brown, and some pinkish layers; thin beds of light-gray clay and laminae of pyritic and lignitic silt.	53	353
Sand, fine, silty, with abundant interstitial clay, gray; many laminae of lignitic silt.	23	376
Sand, fine, with traces of clay and silt, gray and light-brown.	23	399
Clay, dark-gray.	9	408
Sand, fine, some medium sand, traces of silt, light-gray and light-brown, thin beds of clay at 427 and 432 ft and laminae of lignitic silt from 445-447 ft.	58	466
Sand, fine, gray and light-brown; some laminae of clay and pyritic silt.	21	487
Sand, fine, light-gray, and laminae of clayey and silty fine sand; abundant flakes of muscovite.	26	513
Clay, gray.	2	515
Sand, fine, traces of silt, gray, and very thin laminae of clayey and silty fine sand.	29	544
Sand, fine, some very fine sand, gray, some thin laminae of lignitic silt; some thin beds and laminae of clay; and a few thin laminae of pyritic silt.	96	640
Sand, medium, some fine and coarse sand, and a little very coarse sand, gray; some laminae of lignitic silt.	9	649
Clay, gray and dark-gray; thin beds and laminae of sandy clay, and laminae of lignitic sandy clay.	20	669

Table 1.--Geologist's logs of test wells drilled in the mid-island area of western Suffolk County, N. Y. (continued)

S22910T. (continued)

Description	Thickness (feet)	Depth (feet)
Upper Cretaceous--(continued)		
Matawan Group-Magothy Formation, undifferentiated--(continued)		
Sand, fine, some very fine sand, gray, abundant flakes of muscovite; thin beds and laminae of sandy clay and clay; a few laminae of lignitic very fine sand.	26	695
Sand, medium-gray; some fine to very coarse clayey and silty sand.	47	742
Sand, fine to very coarse, gray and light-brown, and granule to large-pebble gravel (up to about 1-inch diameter); much interstitial clay and silt.	43	785
Clay, light-gray, thin streaks of limonitic silt, and embedded granule to medium-pebble gravel (up to about 1/2-inch diameter); some clayey and silty fine to coarse gray sand near bottom.	2	787
Sand, fine to coarse, gray, and light-brown and granule to large-pebble gravel (up to about 1-inch diameter); much interstitial clay and silt.	48	835
Clay, silt, and sandy clay, light-gray, in laminae and thin beds.	19	854
Sand, fine to coarse, silty, gray and light-brown, and granule to medium-pebble gravel (up to about 1/2-inch diameter); laminae and thin beds of clay.	16	870
Raritan formation:		
Clay member:		
Clay, silt, and silty fine sand, light-gray, in laminae and thin beds.	14	884
Clay, grayish-tan; some thin laminae of limonitic silt.	4	888
Sand, fine, silty, traces of clay, light-gray; some medium sand and thin beds of clay.	24	912
Clay, light-gray; laminae and thin beds of silty and sandy clay.	6	918

Table 1.--Geologist's logs of test wells drilled in the mid-island area of western Suffolk County, N. Y. (continued)

S22910T. (continued)

Description	Thickness (feet)	Depth (feet)
Raritan formation--(continued)		
Clay member--(continued)		
Sand, very fine to fine, silty, traces of clay, light-gray; abundant flakes of muscovite.	28	946

S24769. U.S. Geological Survey test well, 600 feet west of centerline of Wicks Road, 45 feet south of centerline of Vanderbilt Motor Parkway, lat 40°48'19" N, long 73°16'03" W, Brentwood, N. Y. Standard rotary hole drilled by C. W. Lauman & Co., Inc., June 1965. Altitude of land surface about 140 feet above mean sea level. Log based on examination of core samples, flume (mud-ditch) samples, driller's log, and electric resistivity log.

Description	Thickness (feet)	Depth (feet)
Pleistocene:		
Upper Pleistocene deposits:		
Sand, coarse, light-brown and tan, and granule to large-pebble gravel.	158	158
Smithtown clay(?):		
Clay, medium- to dark-gray.	14	172
Upper Cretaceous:		
Matawan Group-Magothy Formation, undifferentiated:		
Sand, very fine to medium, mostly fine, light-gray, traces of silt; many thin laminae of light- and dark-gray clay.	27	199
Sand, fine to medium, mostly medium, tan; traces of silt.	23	222
Sand, fine to medium, mostly medium, tan and light-gray, with some pink streaks; traces of silt; some thin lignitic silt laminae.	19	241
Clay and silty clay, light- to dark-gray.	7	248
Sand, very fine to fine, silty, grayish-brown and yellow; many thin laminae of dark-gray clay.	24	272
Sand, very fine to medium, light-gray and light-yellowish-gray; many traces of silt.	16	288
Sand, very fine to fine, light-gray, silty; many thin laminae of lignitic silt, and much interstitial clay.	96	384

Table 1.--Geologist's logs of test wells drilled in the mid-island area of western Suffolk County, N. Y. (continued)

S24769. (continued)

Description	Thickness (feet)	Depth (feet)
Upper Cretaceous--(continued)		
Matawan Group-Magothy Formation undifferentiated--(continued)		
Clay and silty clay, black and medium-gray.	11	395
Sand, very fine to fine, silty, light-gray; some thin laminae of lignitic silt in upper part.	45	440
Clay and silty clay, light- to dark-gray; some thin laminae of lignitic silt and some very fine and fine light-gray sand in upper part.	32	472
Sand, very fine to fine, silty, light-gray; many thin laminae of light- and dark-gray clay and lignitic silt.	45	517
Sand, very fine to fine, light-gray; traces of silt.	12	529
Sand, very fine to medium, light-gray with some pink and tan streaks; many thin laminae of lignitic silt.	23	552
Sand, very fine to coarse, light-gray; many thin laminae of lignitic silt.	23	575
Clay, and silty clay, light- to dark-gray; some thin laminae of fine sand.	13	588
Sand, very fine to medium, light-gray; some coarse sand.	21	609
Clay, silty, light-gray.	6	615
Sand, very fine to coarse, light-gray, some very coarse sand; many traces of silt.	31	646
Clay and silty clay, light-gray; some embedded small-pebble gravel in top few feet.	10	656
Sand, very fine to coarse, and granule to medium-pebble gravel, light-gray, and some very coarse sand and large-pebble gravel, traces of silt and a few thin laminae of light- and medium-gray clay.	37	693

S24769. (continued)

Description	Thickness (feet)	Depth (feet)
Upper Cretaceous--(continued)		
Matawan Group-Magothy Formation, undifferentiated--(continued)		
Sand, very fine to fine, silty, light-gray, much interstitial clay; a few thin laminae of clay and medium to coarse sand.	105	798
Sand, fine to coarse, light-gray; traces of silt and clay.	14	812
Clay, silty, light-gray.	9	821
Sand, very fine to fine, silty, light-gray; many thin laminae of lignitic silt near bottom.	17	838
Raritan Formation:		
Clay member:		
Clay, light- to medium-gray; many thin beds and laminae of silty clay.	20	858

S24772. U.S. Geological Survey test well, at southwest corner, intersection of Vanderbilt Motor Parkway and Islip Avenue (Calebs Path), 65 feet south of centerline of Vanderbilt Motor Parkway, and 200 feet west of centerline of Islip Avenue, lat 40°48'13" N, long 73° 13' 56" W, Brentwood, N. Y. Standard rotary hole drilled by C. W. Lauman & Co., Inc., Aug. 1965. Altitude of land surface about 120 feet above mean sea level. Log based on examination of core samples, flume (mud-ditch) samples driller's log, and electric resistivity and gamma-ray logs.

Description	Thickness (feet)	Depth (feet)
Holocene:		
Fill (various earth materials and concrete fragments).	6	6
Pleistocene:		
Upper Pleistocene deposits:		
Sand, very fine to very coarse, mostly medium to coarse, brown, and granule to large-pebble gravel.	157	163
Smithtown clay(?):		
Clay, dark-olive-gray and medium-olive-brown.	7	170

Table 1.--Geologist's logs of test wells drilled in the mid-island area of western Suffolk County, N. Y. (continued)

S24772. (continued)

Description	Thickness (feet)	Depth (feet)
Upper Cretaceous:		
Matawan Group-Magothy Formation, undifferentiated:		
Sand, very fine, silty, light-gray; some thin laminae of lignitic silt in upper part.	31	201
Sand, very fine to coarse, mostly fine to medium, light-gray; traces of clay and silt, some thin laminae of lignitic silt in middle part.	47	248
Sand, very fine to fine, silty, light-gray; some thin laminae of light- to dark-gray clay, many traces of clay and silt.	47	295
Sand, very fine to coarse, mostly fine to medium, light-yellowish-gray and light-brownish-gray; many traces of clay and silt, some thin laminae of lignitic silt in middle part.	61	356
Sand, very fine to fine, light-gray, light-yellowish-gray, and light-brownish-gray; traces of clay and silt, some thin laminae of clay and lignitic silt.	61	417
Sand, very fine to medium, light-yellowish-gray; traces of clay and silt; some thin clay laminae.	13	430
Sand, very fine to very coarse, mostly fine to medium, light-gray; traces of silt and clay, some thin laminae of clay.	37	467
Sand, very fine, silty, light-gray; much interstitial clay, many thin laminae of lignitic silt.	30	497
Sand, very fine to coarse, mostly fine, light-gray; traces of clay and much interstitial silt, some thin laminae of lignitic silt.	55	552
Clay and silty clay, light-medium-gray and light-gray; some thin laminae of lignitic silt.	31	583
Sand, very fine to coarse, light-gray, traces of clay and silt; many thin laminae of lignitic silt.	56	639
Sand, very fine to fine, light-gray; traces of clay and silt.	5	644

Table 1.--Geologist's logs of test wells drilled in the mid-island area of western Suffolk County, N. Y. (continued)

S24772. (continued)

Description	Thickness (feet)	Depth (feet)
Upper Cretaceous--(continued)		
Matawan Group-Magothy Formation undifferentiated--(continued)		
Sand, very fine to very coarse, mostly fine to coarse, light-gray; traces of clay and silt, a few thin clay laminae.	77	721
Clay, light- to dark-gray; some embedded granule to medium-pebble gravel in lower part.	13	734
Sand, fine to very coarse, mostly coarse, light-gray, and granule to medium-pebble gravel; many laminae and some thin beds of clay.	45	779
Clay, silty and sandy, light-gray.	17	796
Sand, fine to very coarse, mostly coarse, light-gray; many traces of clay and silt.	11	807
Clay, and sandy clay, light-gray.	8	815
Sand, fine to very coarse, mostly coarse, light-gray, and granule to medium-pebble gravel; many thin beds of sandy clay.	71	886
Raritan Formation:		
Clay member:		
Clay, and silty clay, light- to medium-gray; some sandy silt; some thin laminae of lignitic silt.	43	929
Sand, very fine to medium, some coarse sand, light- to medium-gray; much interstitial clay and silt; a few laminae of lignitic silt near bottom.	18	947
Clay, light- to medium-gray, light-pinkish-gray, and light-yellowish-brown.	19	966

Table 1.--Geologist's logs of test wells drilled in the mid-island area of western Suffolk County, N. Y. (continued)

S27739. U.S. Geological Survey test well, 50 feet east of centerline of Landscape Drive, 45 feet south of centerline of Coventry Court, lat 40°46'03" N, long 73°21'48" W, in Wyandanch, Babylon Township, Suffolk County, New York. Standard hydraulic-rotary hole drilled by C. W. Lauman & Co., Inc., April 1966. Altitude of land surface about 140 feet above mean sea level. Log based on examination of core samples, flume (mud-ditch) samples, driller's log, and electric resistivity log.

Description	Thickness (feet)	Depth (feet)
Pleistocene:		
Upper Pleistocene deposits:		
Sand, mostly medium to coarse, light-brown, and granule to large-pebble gravel (up to about 1-1/4 inch diameter).	50	50
Upper Cretaceous:		
Matawan Group-Magothy Formation, undifferentiated:		
Sand, fine to coarse, light-brown; some laminae and thin beds of clay.	18	68
Sand, fine to coarse, light-gray and reddish; many traces of interstitial clay and silt; many thin laminae of silty fine sand; thin laminae of lignite and lignitic silt in lower half.	42	110
Clay, dark-gray.	12	122
Sand, fine, light-brown; much interstitial clay and silt; some laminae and thin beds of clay.	18	140
Sand, very fine to very coarse, mostly medium, light-gray and light-brownish-gray; traces of interstitial clay and silt.	22	162
Sand, very fine to very coarse, mostly medium to coarse, light-gray, light-brownish-gray, and light-yellowish-gray; traces of interstitial clay and silt.	18	180
Sand, very fine to coarse, light-gray, light-brownish-gray, and light-yellowish-gray; many traces of interstitial clay and silt.	32	212
Clay and silty clay, dark-gray; some thin beds of fine sand.	10	222
Sand, silty, fine, light-gray, some laminae and thin beds of fine to medium sand.	14	236

Table 1.--Geologist's logs of test wells drilled in the mid-island area of western Suffolk County, N. Y. (continued)

S27739. (continued)

Description	Thickness (feet)	Depth (feet)
Upper Cretaceous--(continued)		
Matawan Group-Magothy Formation, undifferentiated--(continued)		
Sand, fine to coarse, mostly medium to coarse, light-brown and light-gray; traces of interstitial clay and silt; some laminae of clay.	22	258
Sand, very fine to fine, silty, light-gray and light brownish-gray; much interstitial clay; a few thin laminae of lignitic silt.	22	280
Sand, very fine to coarse, mostly medium, light-yellowish-brown and light-yellowish-gray; traces of interstitial silt.	22	302
Clay, light- to dark-gray.	12	314
Sand, very fine to medium, mostly very fine to fine, light-gray, light-brownish-gray, and light-yellowish-gray; much interstitial silt; many laminae and thin beds of clay, silty clay, and silt.	90	404
Sand, very fine to coarse, mostly fine to medium, light-gray and light-brownish-gray.	16	420
Sand, very fine to very coarse, mostly medium to coarse, light-gray.	24	444
Sand, very fine to coarse, mostly medium, light-gray, traces of interstitial clay and silt.	16	460
Sand, very fine to coarse, mostly medium, light-gray; many thin laminae of lignitic silt, and a few of clay.	87	547
Sand, fine to medium, mostly medium, light-gray; many traces of interstitial clay and silt; a few thin clay beds and laminae of lignitic silt.	34	581
Sand, very fine to coarse, mostly medium, light-gray; traces of interstitial clay and silt.	33	614
Clay, light-gray, and silty fine sand; some medium sand and lignitic silt laminae.	13	627

Table 1.--Geologist's logs of test wells drilled in the mid-island area of western Suffolk County, N. Y. (continued)

S27339. (continued)

Description	Thickness (feet)	Depth (feet)
Upper Cretaceous--(continued)		
Matawan Group-Magothy Formation, undifferentiated--(continued)		
Sand, very fine to coarse, mostly medium to coarse, light-gray and light-yellowish-gray; traces of interstitial clay and silt.	59	686
Clay, medium-gray, and sandy clay; a few thin beds and laminae of fine to medium sand.	4	690
Sand, very fine to coarse, mostly medium, light-gray, traces of interstitial clay and silt.	22	712
Clay, light-gray, and sandy clay.	6	718
Sand, very fine to coarse, mostly medium, light-gray; traces of interstitial clay and silt.	7	725
Sand, very fine to very coarse, mostly medium to coarse, light-gray, and granule to large-pebble gravel (pebbles to about 3/4-inch diameter).	40	765
Clay, light-gray, and silty and sandy clay; a few thin beds and laminae of fine to coarse sand.	5	770
Sand, very fine to very coarse, mostly medium to coarse, light-gray, and granule to medium-pebble gravel (pebbles to about 1/2-inch diameter); traces of interstitial clay and silt; a few thin beds and laminae of clay and clayey and silty sand.	36	806
Clay, light-gray, and silty clay.	4	810
Sand, very fine to coarse, mostly medium, light-gray, light-brownish-gray, and light-yellowish-gray; many traces of interstitial clay and silt; a few thin laminae of clay, silty clay, and silty sand.	54	864
Raritan Formation:		
Clay member:		
Silt, light-gray, some light-yellowish-gray and light-brownish-gray, much interstitial clay; a small amount of very fine sand, and a few thin laminae of lignitic silt.	36	900
Clay, light-gray and medium-gray; some thin beds and laminae of lignite.	25	925

Table 1.--Geologist's logs of test wells drilled in the mid-island area of western Suffolk County, N. Y. (continued)

S29776T. U.S. Geological Survey test well, 210 feet north of centerline of Long Island Expressway westbound access road, 50 feet east of centerline of Round Swamp Road, lat 40°47'02" N, long 73°26'42" W, in Melville, Town of Huntington, Suffolk County, New York. Standard rotary hole drilled by C. W. Lauman & Co., Inc., February 1967. Altitude of land surface about 193 feet above mean sea level. Log based on examination of core samples, flume (mud-ditch) samples, driller's log and electric resistivity and gamma-ray logs.

Description	Thickness (feet)	Depth (feet)
Pleistocene:		
Upper Pleistocene deposits:		
Sand, very fine to very coarse, mostly medium to coarse, and granule to very-large-pebble gravel (up to about 1-1/2 inch diameter), light-brown; some thin beds and laminae of silty and clayey fine sand.	112	112
Upper Cretaceous:		
Matawan Group-Magothy Formation, undifferentiated:		
Sand, very fine to coarse, clayey and silty, light-gray, with light-yellowish-brown and light-reddish-brown streaks.	13	125
Clay, light-yellowish-brown, light-gray, medium-gray and grayish-black.	13	138
Sand, fine to coarse, mostly medium, light- and dark-yellowish-brown, and light-reddish-brown; a few thin beds and laminae of clayey and silty fine sand.	15	153
Sand, fine to coarse, mostly medium, light-yellowish-gray, light-yellowish-brown, and light-brown; traces of clay and silt; a few thin laminae of lignitic silt and fine sand near bottom.	42	195
Sand, fine to medium, silty, light-gray and light-yellowish-gray.	8	203
Sand, fine to coarse, mostly medium, light-gray, light-brown, and light-pinkish-gray; a few thin beds and laminae of light-gray clay.	7	210
Clay, light- to medium-gray, interbedded with light- to dark-gray silty and sandy clay; a few thin laminae of lignitic silt near top; colors become darker toward bottom.	60	270

Table 1.--Geologist's logs of test wells drilled in the mid-island area of western Suffolk County, N. Y. (continued)

S29776T. (continued)

Description	Thickness (feet)	Depth (feet)
Upper Cretaceous--(continued)		
Matawan Group-Magothy Formation, undifferentiated--(continued)		
Sand, very fine to coarse, mostly medium, light-gray and light- and medium-yellowish-gray; traces of interstitial clay and silt; a few thin laminae of lignitic fine sand near top.	38	308
Clay, light-gray, interbedded with light-gray and light-yellowish-gray silty and sandy clay.	22	330
Sand, fine to coarse, mostly medium, light-gray and some light-yellowish-gray; many traces of clay and silt in lower half.	30	360
Sand, very fine to fine, silty, light-gray and light-yellowish-gray; many traces of clay.	12	372
Sand, very fine to coarse, mostly fine to medium, light-gray and light-yellowish-gray; traces of clay and silt; a few thin laminae of light- and dark-gray lignitic fine sand near bottom.	36	408
Sand, very fine to fine, silty, light-gray and light-yellowish-gray; traces of interstitial clay.	14	422
Clay, medium-gray and light-brownish-red, interbedded with similar-colored silty and sandy clay.	48	470
Sand, fine to medium, light-gray; some thin beds and laminae of light-brownish-red clay in upper half.	34	504
Sand, very fine to very coarse, light-gray; many very thin clayey and silty laminae, and a few thin beds of light-brownish-red and light-gray clay; some granule gravel (pebbles to about 1/8 inch diameter) in upper 18 feet; many very thin lignitic silt laminae.	70	574
Sand, medium to very coarse, mostly coarse, light-gray and light-yellowish-gray; many thin beds and laminae of light-gray clay and light-gray silty clay.	50	624
Clay, spotty-colored, light-gray, light-brownish red, and dark-brownish-red; much embedded granule to large-pebble gravel (pebbles up to 1-inch diameter).	5	629

S29776T. (continued)

Description	Thickness (feet)	Depth (feet)
Upper Cretaceous--(continued)		
Matawan Group-Magothy Formation, undifferentiated--(continued)		
Sand, fine to very coarse, mostly coarse, light-gray and light-yellowish-gray, and granule to large-pebble gravel (pebbles up to about 1-inch diameter); some thin beds of gravelly clay; many traces of interstitial clay and silt.	43	672
Clay, light-gray, light-yellowish-gray, and medium-gray; a few laminae of sandy clay near bottom.	20	692
Sand, very fine to medium, mostly fine, light-yellowish-brown; a few thin beds and laminae of light-gray, light-yellowish-gray, and grayish-pink clay; numerous traces of interstitial clay and silt.	34	726
Sand, very fine to medium, mostly fine, light-yellowish-brown, and light-reddish-brown; some thin beds and laminae of light-gray, and light-yellowish clay; much interstitial clay and silt.	16	742
Raritan Formation:		
Clay member:		
Clay, light- to medium-gray, grayish-pink, and light- to dark-yellowish brown.	38	780
Silt, clayey, light- to medium-gray; a little very fine to fine sand throughout; many thin laminae of lignitic and pyritic silt.	40	820
Clay, medium- and dark-gray; grayish-black near bottom.	21	841

S33379T. U.S. Geological Survey test well, 355 feet south of centerline of Chestnut Street, and 165 feet west of centerline of Duncan Avenue, lat 40°49'32"N, long 73°05'59"W, in the village of Lake Ronkonkoma, Town of Brookhaven, Suffolk County, New York. Standard rotary hole drilled by Layne-New York Co., Inc., August 1968. Altitude of land surface about 134 feet above mean sea level. Log based on examination of core samples, flume (mud-ditch) samples, driller's log, electric resistivity log, and gamman-ray log.

Table 1.--Geologist's logs of test wells drilled in the mid-island area of western Suffolk County, N. Y. (continued)

S33379T. (continued)

Description	Thickness (feet)	Depth (feet)
Holocene:		
Loam, sandy.	1	1
Pleistocene:		
Upper Pleistocene deposits:		
Sand, very fine to very coarse, mostly medium to coarse and granule to large-pebble gravel, light-brown; many boulders.	101	102
Sand, very fine to very coarse, mostly medium to coarse, and granule to large-pebble gravel, light-brown.	55	157
Sand, very fine to very coarse, mostly medium, medium-brown.	23	180
Sand, very fine to very coarse, mostly medium to coarse, and granule to large-pebble gravel, light-brown.	264	444
Upper Cretaceous:		
Matawan Group-Magothy Formation, undifferentiated:		
Sand, very fine to medium, mostly very fine, silty, light-gray; a few laminae of lignitic silt.	20	464
Clay, medium and dark gray.	12	476
Clay, silty, light- and medium-gray; many laminae of lignitic silt; a few laminae of fine sand.	22	498
Sand, very fine to coarse, mostly fine to medium, light-gray, traces of interstitial clay and silt.	10	508
Sand, very fine to medium, mostly very fine to fine, silty, light-gray and brownidh-yellow; many laminae of lignitic silt; many traces of disseminated pyrite.	68	576
Sand, very fine to medium, mostly fine to medium, light-gray, interstitial clay and silt throughout, increasing from traces in upper part to much clay and silt in about bottom 10 feet.	30	606
Sand, very fine to fine, clayey and silty, light-gray.	8	614
Sand, very fine to fine, silty, light-gray.	18	632

Table 1.--Geologist's logs of test wells drilled in the mid-island area of western Suffolk County, N. Y. (continued)

S33379T. (continued)

Description	Thickness (feet)	Depth (feet)
Upper Cretaceous--(continued)		
Matawan Group-Magothy Formation, undifferentiated--(continued)		
Sand, very fine to fine, clayey and silty, light-gray; many laminae of lignitic silt; some laminae and thin beds of clay.	66	698
Sand, very fine to coarse, mostly medium, light-gray, traces of interstitial clay and silt.	25	723
Sand, very fine to coarse, mostly medium, light-gray; many laminae of lignitic silt.	25	748
Clay, light- and dark-gray; some laminae and thin beds of very fine to medium sand.	48	796
Sand, very fine to very coarse, mostly medium to coarse, light-gray and light-medium-gray, traces of interstitial clay and silt; some laminae and thin beds of clay and silt.	48	844
Sand, very fine to very coarse, mostly medium to coarse, and granule to large-pebble gravel (pebbles to about 1-inch diameter) light-gray and light-medium-gray, traces of interstitial clay and silt; some laminae and thin beds of clay and silt.	104	948
Sand, very fine to very coarse, mostly medium, light-gray and light-medium-gray traces of interstitial clay and silt; some laminae and thin beds of clay and silt.	54	1,002
Raritan Formation:		
Clay member:		
Clay, light- to dark-gray; a few laminae of silty clay, lignite, and pyrite.	28	1,030
Sand, very fine to medium, mostly fine, light-gray and light-medium-gray, many traces of interstitial clay and silt; some laminae and thin beds of clay.	46	1,076
Sand, very fine to medium, mostly fine, silty, light-gray; a few laminae of pyrite.	14	1,090

Table 1.--Geologist's logs of test wells drilled in the mid-island area of western Suffolk County, N. Y. (continued)

S33379T.

Description	Thickness (feet)	Depth (feet)
Upper Cretaceous--(continued)		
Raritan Formation--(continued)		
Clay member--(continued)		
Clay, medium- to dark (nearly black)- gray; a few laminae and thin beds of light-gray and light-medium-gray clayey and silty sand; many laminae of lignitic silt; a few laminae of pyrite.	102	1,192
Lloyd Sand Member		
Sand, very fine to coarse, mostly medium; and some granule gravel, light-gray, traces of interstitial clay and silt; many laminae and thin beds of clayey and silty sand; some laminae and thin beds of light- to dark-gray clay.	160	1,352
Sand, very fine to very coarse, mostly medium, and some granule gravel, light-gray, traces of interstitial clay and silt; some laminae and thin beds of clayey and silty sand.	206	1,558
Precambrian(?):		
Bedrock:		
Rock, weathered; biotite gneiss(?); highly decomposed to whitish clay at top.	22	1,580